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OF

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

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TRANSACTIONS

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THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

EDITED BY THE SECRETARY

PRINCIPAL OFFICE OF THE SOCIETY
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CONTENTS

PAGE

Index to Papers and Discussions, ... vi

List of Officers, ... vii

Articles of Incorporation, ... ix

Constitution and By-Laws, ... xi

PROCEEDINGS OF THE TWENTY-FIFTH GENERAL MEETING OF THE SOCIETY, HELD IN NEW YORK, NOVEMBER 15 AND 16, 1917.

Introductory Proceedings, ... xix

Report of Secretary-Treasurer, ... xix

Election of New Members, ... xxv, 299

Election of Officers, ... xxv

President's Address, ... xxx

Second Session, Thursday, November 15 71

Third Session, Friday, November 16 100

Fourth Session, Friday, November 16 135

Resolutions Adopted by the Council, November 14, 1917, *in re* War Revenue Act, ... 303

Letter to Junior Members, *in re* Prize Offered Paper by H. L. Aldrich . 305

Banquet 307

Letter of Acceptance of Hon. Josephus Daniels, Secretary of the Navy 309

Remarks by the Toastmaster, Mr. Stevenson Taylor, President of the Society 311

Address of Hon. Josephus Daniels, Secretary of the Navy 317

Address of Rear Admiral Washington Lee Capps 323

Address of Mr. Joseph Wright Powell 328

Address of Rev. Dr. Charles A. Eaton 335

Obituary 341

INDEX TO PAPERS AND DISCUSSIONS

THURSDAY, NOVEMBER 15, 1917.

PAGE

THE SERVICE DEPARTMENT OF A SHIPYARD, ... 1
By Samuel W. Wakeman, Esq., Member.

SHIPBUILDING IN THE GULF STATES AND THE NATURAL RESOURCES AND FACILITIES FAVORABLE THERETO, ... 11
By Charles N. Crowell, Esq., Member.

PROGRESS OF MARINE ENGINEERING AND THE EDUCATION OF THE MARINE ENGINEER, ... 17
By Robert Haig, Esq., Member.

THE EFFECT OF WIND AND FOULING RESISTANCES ON THE U. S. S. NEPTUNE, . 41
By William W. Smith, Esq., Member.

RECENT DEVELOPMENTS IN TANK STEAMER CONSTRUCTION, ... 73
By Robert W. Morrell, M. E., Member.

POWER AND ECONOMY TEST OF THE S. S. PONTIAC, ... 89
By A. George Mattsson, Esq., Member, and Thomas Durkin, Esq.

DEVICES FOR COMPARING THE ROTATION OF SHAFTS, ... 97
By Dr. K. Suyehiro, Member.

FRIDAY, NOVEMBER 16, 1917.

CARGO SHIP LINES OF SIMPLE FORM, ... 101
By Naval Constructor William McEntee, U. S. N., Member.

REMARKS ON LABOR AND PATRIOTISM, ... 109
By Assistant Naval Constructor A. W. Carmichael, Member.

APPLICATION OF ELECTRICITY TO VARIOUS AUXILIARIES ON SHIPBOARD, . . 113
By H. L. Hibbard, Esq., Member.

SUBMARINE HULLS, ... 121
By Naval Constructor E. S. Land, U. S. N., Member.

FABRICATED SHIPS, ... 137
By R. H. M. Robinson, Esq., Member of Council.

THE INFLUENCE OF THE WAR ON SUBMARINE POLICY, ... 145
By Marley F. Hay, Esq., Member.

AN ANALYSIS OF THE PRINCIPLES OF INDUSTRIAL MANAGEMENT, ... 161
By Naval Constructor T. G. Roberts, U. S. Navy, Member.

GYRO SHIP STABILIZERS IN SERVICE, ... 293
By Elmer A. Sperry, Esq., Member.

OFFICERS OF THE SOCIETY

President.
STEVENSON TAYLOR.

Past President and Member.
FRANCIS T. BOWLES.

Past President and Life Associate Member.
ROBERT M. THOMPSON.

Honorary Vice-Presidents.
E. A. STEVENS, F. L. FERNALD, F. E. KIRBY.

Vice-Presidents.
Term expires December 31, 1918:
H. I. CONE, G. W. DICKIE,
LEWIS NIXON, C. H. PEABODY.

Term expires December 31, 1919:
J. W. MILLER, A. P. NIBLACK,
R. M. WATT, W. M. McFARLAND.

Term expires December 31, 1920:
W. F. DURAND, H. L. FERGUSON,
W. L. CAPPS, D. W. TAYLOR.

Members of Council.
Term expires December 31, 1918:
W. J. BAXTER, W. D. FORBES, R. H. ROBINSON,
W. G. COXE, ANDREW FLETCHER, H. A. MAGOUN.

Term expires December 31, 1919:
J. H. LINNARD, J. H. GARDNER, C. P. WETHERBEE,
W. L. R. EMMET, H. C. HIGGINS, C. A. McALLISTER.

Term expires December 31, 1920:
J. W. POWELL, W. A. DOBSON, F. L. DuBOSQUE,
D. H. COX, A. C. PESSANO, H. C. SADLER.

Associate Members of Council.
Term expires December 31, 1918:
E. M. BULL, H. D. GOULDER.

Term expires December 31, 1919:
R. A. C. SMITH, ALBERT W. GOODRICH.

Term expires December 31, 1920:
H. H. RAYMOND, H. L. ALDRICH.

Executive Committee.
STEVENSON TAYLOR, *Ex-Officio.*
WASHINGTON L. CAPPS, F. L. DuBOSQUE,
ANDREW FLETCHER, J. W. POWELL,
W. M. McFARLAND, DANIEL H. COX, *Ex-Officio.*

Secretary-Treasurer.
DANIEL H. COX.

ARTICLES OF INCORPORATION

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

State of New York,
City and County of New York.

We, the subscribers, Wm. H. Webb, Chas. H. Cramp, George E. Weed, H. Taylor Gause, William T. Sampson, Horace See, Frank L. Fernald, Francis T. Bowles, Washington L. Capps, Edwin D. Morgan, George W. Quintard, Harrington Putnam and Jacob W. Miller, being persons of full age and citizens of the United States, of whom a majority—namely, William H. Webb, George E. Weed, Horace See, Edwin D. Morgan, George W. Quintard, Harrington Putnam, Frank L. Fernald, and Jacob W. Miller are citizens of and residents of and within this State, desiring to associate ourselves for scientific purposes under, and pursuant to, an Act of the State of New York providing for the incorporation of benevolent, charitable, scientific, and missionary societies, passed April 12, 1848, and the several acts amending or supplementing the same, do hereby, in accordance with the requirements thereof, certify as follows:—

First. The name of title by which the Society shall be known in law is The Society of Naval Architects and Marine Engineers.

Second. The particular business and objects of such Society are the promotion of practical and scientific knowledge in the arts of shipbuilding and marine engineering and the allied professions, and in furtherance of this object, to hold meetings for social intercourse among its members, and the reading and discussion of professional papers, and to circulate by means of publication the knowledge thus obtained.

Third. The number of directors, trustees, or managers to manage the Society shall be seven, and shall consist of a President, a Secretary, and five Members of Council.

Fourth. The names of the trustees, directors, or managers of the Society for the first year of its existence are:—President, Clement A. Griscom; Secretary, Washington L. Capps; Members of Council, Francis T. Bowles, H. Taylor Gause, Chas. H. Loring, Lewis Nixon, Harrington Putnam.

Fifth. The business of the Society is to be conducted, and its place of business and principal office is to be located, in the City and County of New York.

In Witness Whereof, we have made, signed and acknowledged this Certificate, this 28th day of April, 1893.

WILLIAM H. WEBB.	FRANCIS T. BOWLES.
CHAS. H. CRAMP.	W. L. CAPPS.
H. T. GAUSE.	E. D. MORGAN.
GEORGE E. WEED.	GEORGE W. QUINTARD.
W. T. SAMPSON.	HARRINGTON PUTNAM.
HORACE SEE.	J. W. MILLER.
F. L. FERNALD.	

City and County of New York, *ss:*

On this 28th day of April, 1893, before me personally appeared William H. Webb, Charles H. Cramp, H. Taylor Gause, George E. Weed, William T. Sampson, Horace See, Frank L. Fernald, Francis T. Bowles, Washington L. Capps, and Edwin D. Morgan, to me known and known to me to be the persons described in and who executed the foregoing certificate, and severally acknowledged to me that they executed the same.

James Forrester,
Notary Public, Kings Co., Cert. N. Y. Co.

City and County of New York, *ss:*

On this 1st day of May, 1893, before me personally appeared George W. Quintard and Harrington Putnam, to me known and known to me to be the individuals described in and who executed the foregoing certificate, and they severally acknowledged to me that they executed the same.

James Forrester,
Notary Public, Kings Co., Cert. N. Y. Co.

City and County of New York, *ss:*

On this 9th day of May, 1893, before me personally appeared Jacob W. Miller, to me known and known to me to be one of the individuals described in and who executed the foregoing certificate, and he duly acknowledged to me that he executed the same.

James Forrester,
Notary Public, Kings Co., Cert. N. Y. Co.

(Endorsed.)

Upon reading the within Certificate for the Incorporation of the Society of Naval Architects and Marine Engineers, I hereby approve and consent to the incorporation thereof and the within Certificate and filing thereof, and direct that the same be filed in the office of the Clerk of the City and County of New York.

Dated New York, May 10, 1893.

Edwd. Patterson,
Justice of the Supreme Court in the State of New York,
in and for the City and County of New York.

CONSTITUTION AND BY-LAWS OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

Article I.

Name and Object.

1. The name of the Association shall be "The Society of Naval Architects and Marine Engineers."

2. Its object shall be the promotion of the art of shipbuilding, commercial and naval.

3. In furtherance of this object, annual meetings shall be held for the reading and discussion of appropriate papers and interchange of professional ideas, thus making it possible to combine the results of experience and research on the part of shipbuilders, marine engineers, naval officers, yachtsmen, and those skilled in producing the material from which ships are built and equipped.

Article II.

Membership.

1. The Society shall consist of Members, Associates, Juniors, Honorary Members and Honorary Associates.

2. *Members.*—(1) The class of Members shall consist exclusively of Naval Architects, Marine and Mechanical Engineers, including Professors of Naval Architecture or Mechanical Engineering in colleges of established reputation.

(2) A candidate for this class must not be less than twenty-eight years of age and comply with the following regulations: He shall submit to the Council a statement showing that he has been engaged in the practice of his profession, in a responsible capacity, for at least five years, and setting forth the grounds upon which he bases his claim to membership. This statement shall be signed by three Members, who shall certify to their personal knowledge of the candidate and approval of his statement.

(3) In the case of persons not American citizens, the signatures of three Members shall be required in confirmation of their personal knowledge of the candidate's scientific attainments.

(4) If three-fourths of the members of the Council present are in favor of the admission of the candidate his name shall be submitted to the Members of the Society at the next meeting; the voting to be by ballot, should a ballot be demanded.

3. *Associates.*—(1) The class of Associates shall consist of persons who, by profession, occupation, or scientific attainments, are qualified to discuss the qualities of a ship.

(2) Candidates for this class shall submit to the Council a written statement of their qualifications for membership; this shall be signed by two Members or Associates who shall certify to their personal knowledge of the candidate and approval of his statement. If con-

sidered by three-fourths of the Council present duly qualified for associate membership their names shall be submitted to the Society at the next meeting, to be voted upon by the Members and Associates; the voting to be by ballot, should a ballot be demanded.

4. The proportion of favorable votes for deciding the election of Members and Associates shall be at least four-fifths of the number recorded.

5. *Juniors.*—(1) The class of Juniors shall consist of graduates of technical schools of established reputation, or persons who have had not less than two years' practical experience in marine engine works or shipyards.

(2) Candidates must be at least eighteen years of age and certify their intention to continue in the profession and become naval architects or marine engineers.

(3) Juniors shall be eligible for transfer to the class of Members or Associates after fulfilling the necessary conditions; when they are twenty-eight years of age they shall be offered the option of being transferred to the class of Members or Associates in conformity with their qualifications; but if they do not accept such offer or do not qualify, they shall be dropped from the rolls of the Society.

(4) The admission of Juniors shall be by a favorable vote of three-fourths of the members of the Council present.

(5) Juniors shall have no voice in the government of the Society or admission of members.

6. *Honorary Members and Honorary Associates.*—The Council may elect Honorary Members and Honorary Associates, the total number not to exceed twenty-five. They shall be persons of acknowledged eminence in their profession upon whom the Council may see fit to confer an honorary distinction.

7. *Benefactors and Permanent Members.*—The Council may establish a list of Benefactors. It may also elect as Permanent Members of the Society such Members or Associate Members as shall, in the opinion of the Council, by reason of notably liberal contributions to the Society, merit special recognition. Permanent Members shall, from the date of their election, be relieved from annual dues, and shall have the right, subject to the approval of Council, to designate by will or otherwise, their successors. The conditions to be met before placing any name on the list of Benefactors and the regulations governing the election of Permanent Members shall be prescribed by the Council.

Article III.

Dues, Suspension and Expulsion of Members.

1. The entrance fees, payable on admission to the Society, shall be as follows:—

Members and Associates, ten dollars; Juniors, five dollars; Honorary Members and Honorary Associates, no fees.

2. The annual dues shall be as follows:—

Members and Associates, ten dollars; Juniors, five dollars; Honorary Members and Honorary Associates, no dues.

3. A member transferred from one grade to another shall pay the difference between the entrance fees of the two grades, and his annual dues shall be those of the grade to which transferred.

4. The annual dues shall be payable in advance on the first day of January. The Secretary shall notify each member of the amount due for the ensuing year at the time of giving

notice for the annual meeting. On notification of his election each member shall pay his entrance fee, but annual dues for the current year shall not be required unless he desires to receive the published transactions of the Society for that year, in which case he shall pay five dollars in addition to the entrance fee.

5. Members and Associates can compound for all future dues and become Life Members or Life Associates by making a single payment of two hundred dollars and signing an agreement to conform to any future amendments to the Constitution and By-Laws.

6. Members are entitled to no return of fees upon severing their connection with the Society.

7. Any member whose dues are more than three months in arrears shall be notified by the Secretary. Should his dues become six months in arrears he shall be again notified by the Secretary and his rights as a member suspended. Should his dues become one year in arrears the delinquent member shall forfeit his membership in the Society unless the Council may deem it expedient to extend the time of payment.

8. The Council may, in its discretion, temporarily suspend the annual payment of dues by any member whose circumstances have become such as to make such payment impossible, and may, under similar circumstances, remit the whole or part of dues in arrears.

9. No name shall be entered on the rolls as Member, Associate or Junior, nor shall the privileges of membership be enjoyed until the payments required in paragraphs 1 to 4 of this article have been made; if the payment be delayed for more than six months from the date of election, the same shall be void unless the Council otherwise direct.

10. (1) Should the expulsion of any member be judged expedient by five or more members, they must draw up and sign a proposal requesting such expulsion, delivering the same to the Secretary, to be laid before the Council.

(2) If the Council do not find reason to concur in the proposal, no entry thereof shall appear in the minutes, nor shall any public discussion thereon be permitted.

(3) If, however, the Council find the charges contained in the proposal for expulsion substantiated, the accused member shall be notified and given an opportunity to resign. If he avails himself of this privilege, no entry shall be made on the minutes nor public discussion in the case be permitted. But if he declines to resign and offers no satisfactory explanation of the charge, the whole case shall be submitted to a special meeting of the Society.

(4) If two-thirds of the members at this special meeting (providing there be not less than twenty present) vote for expulsion, the Chairman of the meeting shall cause the accused to be expelled from the Society, and direct the Secretary to notify the accused of this action.

Article IV.

Officers.

1. The officers of the Society shall consist of a President, Past Presidents, Honorary Vice-Presidents, twelve Vice-Presidents, twenty-four members of Council, and a Secretary and Treasurer.

2. Both Members and Associates are eligible for the offices of President, Honorary Vice-President, Vice-President and members of Council, but three-fourths of the Council shall be Members.

3. Prior to the date of the annual meeting of the Society of the year with which the term of the President expires, the Council shall nominate a candidate for the office of Presi-

dent, whose name shall be presented to the Society for election at the annual meeting. Any other candidate whose nomination, signed by at least sixty Members and Associates, shall have been submitted to the Secretary prior to the annual meeting shall also be presented. The candidate receiving the highest number of votes shall be the President for the ensuing three years. The first President under this rule was elected at the annual meeting in 1906 and his term of office began January 1, 1907. The President shall not be eligible for election as his own successor.

4. (1) The term of office of the Vice-Presidents shall be three years. The terms of the Vice-Presidents which, under a previous provision of the Constitution, should have expired in 1911 and 1912 are regarded as having expired on December 31, 1911. Those terms which, under the same conditions, should have expired in 1913 and 1914 are regarded as having expired on December 31, 1912; those which should have expired in 1915 and 1916 are regarded as having expired on December 31, 1913. Beginning with the four Vice-Presidents elected for the term ending December 31, 1914, there shall be four Vice-Presidents elected each year to take the place of those whose terms expire. The Vice-Presidents to fill the vacancies occurring each year in any class shall be elected by the Council from their own membership. Retiring Vice-Presidents shall be eligible for re-election.

(2) Honorary Vice-Presidents shall be chosen from the list of Vice-Presidents who have had at least ten years' service as Vice-President. They shall be chosen at the meeting of the Council next prior to the annual general meeting of the Society and must be the unanimous choice of all members of Council present. Not more than two Vice-Presidents may be elected Honorary Vice-Presidents in any one year.

5. (1) The term of office of the Members and Associate Members of Council shall be three years. Prior to August 1 of each year the Secretary shall mail to each Member and Associate a list of the names of the Members and Associate Members of Council whose terms expire with the current year, and shall enclose a blank on which each Member may, if he so desires, nominate one additional candidate for Member of Council and one additional candidate for Associate Member of Council; and each Associate Member may, if he so desires, nominate one additional candidate for Associate Member of Council. No nominations received by the Secretary after August 31 shall be considered.

(2) Prior to September 1 of each year the President shall appoint a nominating committee of five, at least three of whom shall be Members. This committee shall scrutinize the nomination slips sent in by Members and Associates and prepare a ballot. This ballot shall contain the names of all the retiring Members and Associate Members of Council who shall not have declined re-election and a sufficient number of additional names to make a total of nine candidates for Member of Council and three candidates for Associate Member of Council. The names listed on the ballot, other than those of retiring Members and Associate Members of Council, shall be chosen by the nominating committee from those who have received the highest number of votes on the nominating lists returned by Members of the Society.

(3) Should the number of names which have received at least ten votes in the case of nominees for Members of Council and five votes in the case of nominees for Associate Members of Council be insufficient to complete the number on the ballot list above provided for in sub-paragraph (2), the nominating committee shall add enough names to bring the total on the ballot up to nine candidates for Member and three candidates for Associate Member of Council.

(4) The ballots shall be sent by mail as soon as possible after September 1 of each year to all Members and Associate Members of the Society. Each Member may vote for not more than six Members of Council and two Associate Members of Council, and each Associate may vote for not more than two Associate Members of Council. The ballots shall be returned by mail to the Secretary and canvassed by a committee of three Members appointed by the President. This canvassing committee shall report the results of the election to the Council at its meeting immediately prior to the annual meeting of the Society.

(5) When the ballots have been sent out by the Secretary, should there be a desire on the part of Members or Associates to suggest another list of candidates for the Council, any twenty Members and Associates may unite in submitting another list to the Secretary which shall also be sent out to the membership to be considered in connection with the list already sent. In any event, the six Members who receive the highest number of votes shall be declared elected Members of Council, and the two Associates receiving the highest number of votes shall be declared elected Associate Members of Council, in each case for a term of three years.

6. A vacancy in the office of President shall be filled by ballot by the Council from the list of Past Presidents, Honorary Vice-Presidents and Vice-Presidents until the end of the year in which it occurs. At the annual meeting of that year a new President shall be elected for three years in the manner prescribed in paragraph 3. A vacancy in the office of member of Council shall be filled by the Council for the unexpired portion of the term of the Member or Associate causing the vacancy.

7. The President, Past Presidents, Honorary Vice-Presidents and Vice-Presidents shall be *ex-officio* members of Council.

8. The Council may hold meetings subject to the call of the President, as often as the interests of the Society may demand.

9. At all meetings of Council seven members shall constitute a quorum.

10. The Secretary and Treasurer shall be elected annually by the Council, but may be removed at any time by a majority vote of the Council after due notice has been given.

11. The Secretary must be a Member of the Society.

Article V.

Management.

1. (1) The President shall have general supervision over the affairs of the Society, appoint special committees, and preside at the annual general meetings. He shall be *ex-officio* member of all committees.

(2) In the absence of the President, one of the Past Presidents, Honorary Vice-Presidents or Vice-Presidents, in the order of seniority as determined by original accession to, or election in, their respective grades, shall preside and perform all the duties of the President; where there is the same date of seniority, the alphabetical order will govern. Provided, however, that for the annual meeting of the Society or for any other special occasion when it is known that the President cannot attend and preside, the Executive Committee shall, in its discretion, select and designate as Acting President any one of the Past Presidents, Honorary Vice-Presidents, Vice-Presidents or members of Council, who shall act for

the President in his temporary absence and shall perform all the duties which would devolve upon that officer during such Annual Meeting or on such special occasion.

2. (1) The direct management of the Society shall be vested in an Executive Committee of seven, composed of five members of Council, elected annually by the Council, and the President and the Secretary of the Society *ex-officio*. At least three of the five elective members of the committee shall be Members of the Society.

(2) Meetings of the Executive Committee may be held at any time subject to the call of the Chairman; and four members shall constitute a quorum for the transaction of any business that may be properly brought before the Committee.

3. The Executive Committee shall manage the affairs of the Society in conformity with the laws under which it is incorporated and the provisions of this Constitution. It shall direct the investment and care of the funds of the Society; make appropriations for specific purposes; arrange for the reading and publication of professional papers; take measures to advance the interests of the Society, and generally direct its affairs under such regulations as the Council may from time to time prescribe.

4. The Executive Committee shall make an annual report to the Society, transmitting the report of the Secretary and Treasurer, and of any special committee which may have been ordered.

5. (1) The Secretary shall be the Executive Officer of the Society under the immediate direction of the President and the Executive Committee.

(2) He shall prepare the business for the annual meetings and record the proceedings thereof.

(3) He shall be responsible for all expenditures and certify the accuracy of all bills or vouchers upon which money has been paid, and he shall conduct the correspondence of the Society and keep full records of the same.

6. The Treasurer shall see that all money due the Society is collected and carefully invested in such manner as the Executive Committee may direct. If considered advisable by the Council, the duties of Treasurer may be performed by the Secretary.

7. The accounts of the Secretary and Treasurer shall be audited annually in such manner as the Executive Committee may direct.

Article VI.

Meetings.

1. There shall be at least one annual general meeting of the Society for the reading and discussion of professional papers, election of officers for the ensuing year, and transaction of such other business as may be brought before it. The time and location of this meeting shall be determined by the Council at least three months prior to the date fixed.

2. Special meetings may be called by the Executive Committee at the request of twenty members, which request shall state the purpose of the meeting. The call for such meetings shall be issued ten days in advance, and shall state the purpose thereof. At these meetings thirty members shall constitute a quorum.

3. The Society may adopt, from time to time, such rules as it may think proper for the order of business at its meetings.

Article VII.

Regulations and By-Laws.

1. The Council shall have authority to establish such by-laws and regulations as may be necessary for the government of the Society in the conduct of its affairs, provided that such by-laws and regulations do not conflict with the provisions of this Constitution and that they are approved by a two-thirds vote of the members of Council present at any meeting regularly called for the consideration of same. If, however, objection be made by any member of Council to a by-law or regulation so proposed, it must be submitted in writing for the action of the entire Council and will not be finally adopted unless a majority of the Council signifies its approval.

Article VIII.

Amendments.

1. Proposed amendments to the Constitution must be reduced to writing and signed by not less than ten members. They shall be forwarded to the Secretary at least ten days before the annual general meeting, and shall be immediately forwarded to the Council for its consideration. If a majority of the Council approve the proposed amendment it shall be presented to the Society at the next ensuing general meeting for discussion; if approved by two-thirds of the members present voting by ballot, if a ballot be demanded, it shall be adopted.

INTRODUCTORY PROCEEDINGS

MINUTES OF THE TWENTY-FIFTH ANNUAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS, HELD AT THE ENGINEERING SOCIETIES BUILDING, NEW YORK CITY, THURSDAY AND FRIDAY, NOVEMBER 15 AND 16, 1917.

FIRST SESSION.

THURSDAY MORNING, NOVEMBER 15, 1917.

The President, Mr. Stevenson Taylor, called the meeting to order at 10.30 a.m.

THE PRESIDENT:—Owing to the exigencies of war business our secretary is in Washington this morning, but Assistant Naval Constructor A. W. Carmichael, U. S. N., has kindly offered to take his place, and I will ask him to present to you a brief synopsis of the annual report of the Secretary-Treasurer, copies of which have been printed and distributed.

Acting Secretary Carmichael presented the following report:—

REPORT OF SECRETARY-TREASURER

NOVEMBER 15, 1917.

To the Council of The Society of Naval Architects and Marine Engineers:—

GENTLEMEN:—I have the honor to submit the following report showing the condition of the Society at the close of the fiscal year ended October 31, 1917.

The membership of the Society November 1, 1917, was as follows:—

Class of Members	Membership November 1, 1916	Elected at 1916 Meeting	Promotion, Associate to Member	Promotion, Junior to Associate	Reinstated	Suspended by Council	Membership at close Annual Meeting 1916	Deaths 1916-1917	Resignations 1916-1917	Membership November 1, 1917
Members	589	68	+1	—	1	8	651	6	5	640
Associates	173	28	—1	+1	2	4	199	4	5	190
Juniors	22	9	—	—1	—	—	30	1	—	29
Life Members	5	—	—	—	—	—	5	—	—	5
Life Associates	5	—	—	—	—	—	5	—	—	5
Honorary Members	1	—	—	—	—	—	1	—	—	1
Honorary Associates	2	—	—	—	—	—	2	—	—	2
Totals	797	105	—	—	3	12	893	11	10	872

RECEIPTS.

From November 1, 1916, to October 31, 1917, inclusive.

Entrance fees of new members for the year ending December 31, 1917:—		
Life Members	$200 00	
Members	690 00	
Associates	260 00	
Juniors	55 00	
		$1,205 00
Dues for the year ending December 31, 1917:—		
Members and Associates	$7,070 00	
Juniors	110 00	
		7,180 00
Dues for the year ended December 31, 1916:—		
Members and Associates	$540 00	
Juniors	5 00	
		545 00
Dues for the year ended December 31, 1915:—		
Members and Associates	$170 00	
Juniors	5 00	
		175 00
Dues for the year ended December 31, 1914:—		
Members		70 00
Dues for the year ended December 31, 1913:—		
Members		10 00
Dues paid in advance:—		
For the year ending December 31, 1918	$60 00	
For the year ending December 31, 1919	10 00	
		70 00
Entrance fees paid in advance for meeting November, 1917		20 00
Dues in arrears paid by reinstated member		60 00
Total fees and dues collected		$9,335 00
Sales of publications:—		
Society transactions to members and dealers	$1,025 00	
Special editions of papers	67 50	
		1,092 50
Exchange on remittances members' dues		2 64
Banquet, Annual Meeting, 1916		1,928 25
Banquet, Annual Meeting, 1917		165 00
Sale of office material		12 16
Insurance refund		1 50
Panama fund		5 00
Rent of rooms		24 00
Interest:—		
From investments	$860 00	
From bank balances	21 90	
		881 90
Total receipts		$13,447 95
Balance, cash in bank and on hand November 1, 1916		1,340 79
		$14,788 74

STATEMENT.

DISBURSEMENTS.

From November 1, 1916, to October 31, 1917, inclusive.

Publications:—		
Printing Volume No. 24	$3,972 11	
Membership Year Book and forwarding	343 30	
Printing preliminary papers	1,400 26	
Forwarding volumes and papers	83 63	
Storage of volumes	131 71	
		$5,931 01
Rent of safe deposit box, Franklin Trust Company		5 00
Expenses, 24th Annual Banquet, November, 1916		2,247 25
Expenses, 24th Annual Meeting, November, 1916		697 22
Expenses, 25th Annual Meeting, November, 1917		53 75
Exchange on remittances, members' dues		5 22
Salaries and clerical expenses		2,019 88
Audit of books and accounts to November 1, 1916		180 00
Rent of Society rooms		588 00
Office expenses, postage, stationery, etc.		557 29
Accrued interest on Liberty Bonds purchased		2 52
Investment, purchase of Liberty Bonds:—		
First Issue	$1,000 00	
Initial deposit for Second Issue	20 00	
		1,020 00
Total disbursements		$13,307 14
Balance, cash October 31, 1917:—		
In Franklin Trust Company	$1,453 41	
On hand	28 19	
		1,481 60
		$14,788 74

DEATHS (11).

Members (6).

W. I. Babcock.
Frederick H. Chase.
Charles E. Hyde.
Oliver Z. Howard.
William D. Kearfott.
George E. Weed.

Associates (4).

William Conant Church.
John S. Hyde.
James R. Raymond.
George A. White.

Junior (1).

Prentiss Lingan.

RESIGNATIONS (10).

Members (5).

John J. Herrick.
Ernest N. Janson.
Edwin G. Kintner.
Walter R. Sexton.
Yasnichi Sugitani.

Associates (5).

Joseph E. Craig.
Henry C. Dalton.
Henry S. Grove.
Charles H. MacDonald.
H. O. Nickerson.

The following delinquencies exist in the payment of dues:—

For the year ended December 31, 1913:—		
Members		$30 00
For the year ended December 31, 1914:—		
Members	$100 00	
Associates	50 00	
		150 00
For the year ended December 31, 1915:—		
Members	$270 00	
Associates	90 00	
		360 00
For the year ended December 31, 1916:—		
Members	$460 00	
Associates	240 00	
Juniors	10 00	
		710 00
For the year ending December 31, 1917:—		
Members	$1,000 00	
Associates	395 00	
Juniors	35 00	
		1,430 00
Total outstanding dues at October 31, 1917		$2,680 00

Statement of Resources and Liabilities.

RESOURCES.

Membership dues		$2,680 00	
Deductions:—			
Deaths	$30 00		
Resignations	250 00		
Doubtful accounts	200 00		
		480 00	
			$2,200 00
Accrued interest on municipal bonds, due November 1, 1917			157 50
Due from dealers and individuals for volumes			599 29
Office furniture and equipment at 30% of cost			885 00
Publications on hand:—			
Previous to volume No. 18 at 50% of cost; Volumes Nos. 19 to 24, inclusive, at cost			6,092 66
Investments:—			
Municipal bonds, City of New York, at par		$12,000 00	
4 Baltimore and Ohio R. R. bonds, 1933 Convertible, at cost		3,925 00	
3 Central Pacific Railway Co. bonds, 1949 1st Refunding, at cost		2,651 25	
2 Morris and Essex bonds, 2000 1st Refunding, at cost		1,732 50	
First Issue Liberty Loan		1,000 00	
Initial deposit Second Issue Liberty Loan		20 00	
			21,328 75
Cash on deposit, Franklin Trust Company		$1,453 41	
Cash on hand		28 19	
			1,481 60
Total resources			$32,744 80

LIABILITIES.

Annual banquet 1917, paid in advance	$165 00
Membership fees and dues paid in advance	90 00
Volume paid for in advance	10 00
Total liabilities	$265 00
Society's present worth at October 31, 1917 *	32,479 80
	$32,744 80

*By the provisions of the Endowment Fund resolution adopted in 1914, the position of the Society's present worth at October 31, 1917, is as follows:—

Balance at November 1, 1916		$14,255 00
Additions 1916-1917:		
Membership entrance fees	$1,205 00	
Investment income, municipal bonds	490 00	
		1,695 00
Balance at October 31, 1917, Endowment Fund		$15,950 00
Net assets other than Endowment Fund		16,529 80
		$32,479 80

The financial statements have been verified by Wechsler & Mills, Certified Public Accountants of New York.

Respectfully submitted,

DANIEL H. COX,
Secretary-Treasurer.

Acting Secretary Carmichael:—Gentlemen, this report is before you, and shows an increase in membership over the report of last year of seventy-eight members, which, with the new applications coming in at this meeting, will bring our membership up to about one thousand members. There is a marked improvement in the collection of dues, there being an increase of about $1,000 over that of last year. There is, however, an increase in the amount of dues due from members, which is owing to the increase in membership.

Greater interest in the work of the Society is shown, not only in the increased membership, but in the fewer number of resignations.

In the matter of our resources, the Society is still showing improvement, showing an increase of about $1,700. Our Endowment Fund has also advanced about $1,700. Altogether, the report shows a very favorable condition of affairs.

The President:—You have the printed report of the Secretary-Treasurer in your hands, and have heard the comments of the Acting Secretary. What is your pleasure?

Professor Herbert C. Sadler, *Member of Council:*—I move that the report be accepted.

The motion was duly seconded, put to vote and carried.

The President:—Will the gentlemen please rise.

The Society has been sorely stricken during the past year in the matter of deaths of its members. Before I read in memoriam the names of these deceased members I will take the liberty of referring to my personal relations with four of them.

I have known Mr. W. I. Babcock since he was a very young man, commencing his career as a naval architect, and we have been warm and staunch friends all these years. He has been a member with myself of the Engineers' Club, and a very popular member he was. His work in his lifetime speaks for itself.

I had the pleasure of knowing Mr. Charles E. Hyde for a great many years. I knew him when he was the chief engineer at the Bath Iron Works and from that time up to the time of his death.

My dear old friend George E. Weed—what can I say about him? There is nothing that I can say too great or too good for Mr. Weed. I became associated with him very early in my career, and while he was not very many years older than I, I learned very soon to hold him in especial regard. Like Mr. Babcock, he was a member of the Engineers' Club, treasurer of it for a good many years, and he was one of the original members of this Society.

Mr. John S. Hyde—that name brings back one of my pleasantest memories, one of the kindest things ever done for me was done by Mr. Hyde's father, General Hyde. Mr. John Hyde himself came to New York before he took hold of the Bath Iron Works for the second time, that is to say, after the collapse of the shipbuilding combination in which the Bath Iron Works had been placed, and he asked me what I thought about his buying back the Bath Iron Works, and I am proud now to say that I advised him strongly to do so, that there was an opportunity there, I thought, for great success. That he with his corps has made a great success of the Bath Iron Works will ever be remembered to his credit.

The names of those who have passed this last year are:—

Members:—W. I. Babcock, Frederick H. Chase, Oliver Z. Howard, Charles E. Hyde, William D. Kearfott and George E. Weed.

Associates:—William Conant Church, John S. Hyde, James R. Raymond, and George A. White.

Junior:—Prentiss Lingan.

We hold these names in memory dear.

It is now my duty to announce to you the result of the meeting of the Council yesterday afternoon, at which certain elections were made.

There were elected as Vice-Presidents for the term expiring December 31, 1920:—W. F. Durant, W. L. Capps, D. W. Taylor, H. L. Ferguson.

Vice-President for term expiring December 31, 1918, vice G. E. Weed, deceased:—C. H. Peabody.

Members of Council for term expiring December 31, 1920:—D. H. Cox, J. W. Powell, W. A. Dobson, H. C. Sadler, F. L. DuBosque, A. C. Pessano.

Associate Members of Council for term expiring December 31, 1920:—H. L. Aldrich, H. H. Raymond.

Associate Member of Council, term expiring December 31, 1918, vice J. S. Hyde, deceased:—E. M. Bull.

Executive Committee for the year 1918:—Stevenson Taylor, *ex-officio,* Andrew Fletcher, W. M. McFarland, F. L. DuBosque, J. W. Powell, D. H. Cox, *ex-officio.*

Secretary and Treasurer for the year 1918:—D. H. Cox.

Committee on Papers:—W. M. McFarland, F. L. DuBosque, H. L. Aldrich.

All, I trust, meets with your complete satisfaction, and I ask your approval. Those in favor please say "Aye," contrary-minded, "No." The action of the Council in these elections is approved.

The Secretary will now read the list of new members. As it is a long list, Mr. Secretary, perhaps it would be as well to read the surnames only.

Life Associate Member (1).

Herbert L. Aldrich, Publisher, International Marine Engineering, Printing Crafts Building, New York, N. Y.

Members (72).

George P. Aborn, Manager, Blake & Knowles Works of the Worthington Pump and Machinery Corporation, East Cambridge, Mass.

Jakob L. Bergvall, Leading Draughtsman, Bethlehem Shipbuilding Corporation, Fore River Plant, Quincy, Mass.

Leonard R. Bester, Marine Engineer and Naval Architect, Todd Shipyards Corporation, and Chief Draughtsman of White Fuel Oil Engineering Corporation, 164 West 96th Street, New York, N. Y.

Charles S. Bookwalter, Naval Architect, Emergency Fleet Corporation, District Office, New York City, 115 Broadway, New York, N. Y.

Robert W. Bruce, Naval Architect, Harlan & Hollingsworth Corporation, Wilmington, Del.

David B. Carswell, Assistant General Superintendent, Detroit Shipbuilding Company, Detroit, Mich.

Edward E. Carpenter, Executive Engineer for Messrs. Sanderson & Porter, 52 William Street, New York, N. Y.

Angelo Conti, Assistant Chief Engineer, Emergency Fleet Corporation, 1459 N Street, N. W., Washington, D. C.

John C. Craven, Naval Architect, Federal Shipbuilding Company, 54 Dey Street, New York, N. Y.

Albert Wm. Cross, Assistant to General Manager, The American Shipbuilding Company, Cleveland, Ohio.

George Dame, Assistant Superintendent, Robins Dry Dock and Repair Company, 47 Dikeman St., Brooklyn, N. Y.

G. A. Dickie, Assistant Superintendent, Raymond Shipyard, Raymond, Wash.

Ernest H. Dendel, Superintendent, Tietjen & Lang Dry Dock Company, Hoboken, N. J.

W. E. Dowd, Jr., Manager, Marine Department, Power Specialty Company, 111 Broadway, New York, N. Y.

Jas. B. Dunlop, Ship and Engineer Surveyor to the American Bureau of Shipping, 66 Beaver Street, New York, N. Y.

Wm. A. Ebsen, Manager, Blake & Knowles Steam Pump Works, 115 Broadway, New York, N. Y.

Lyman J. Fisher, Proprietor, Charles Hubbard Company, 81 Fulton Street, New York, N. Y.

David Gaehr, Designing and Contracting Engineer; also Instructor in Engineer's School of the Lake Carriers' Association, Rockefeller Building, Cleveland, Ohio.

Southmayd Hatch, Assistant in charge of repairs to vessels of Standard Transportation Company, 26 Broadway, New York, N. Y.

Howard H. Hoffman, Assistant Chief Hull Draughtsman, Lake Torpedo Boat Company, Bridgeport, Conn.

Ernest L. Jahncke, President Jahncke Shipbuilding Corporation, also President The Jahncke Navigation Company, 814 Howard Avenue, New Orleans, La.

Alfred E. Jordan, Surveyor, Salvage Association, 68 Broad Street, New York, N. Y.

Henry H. W. Keith, Lieut. (J. G.), U. S. N. R. F., Navy Yard, Boston, Mass.

John Kemp, Chief Engine Draughtsman, Federal Shipbuilding Company, 54 Dey Street, New York, N. Y.

Martin G. Kindlund, Naval Architect, Kindlund & Drake, 17 Battery Place, New York, N. Y.

Percy E. Kriebel, Resident Engineer, N. Y. Marine Department, American Engineering Company, 100 Broadway, New York, N. Y.

Konrad Langer, Chief Engineer, Baltimore Dry Dock & Shipbuilding Company, Baltimore, Md.

Frederich D. Lawley, Superintendent, Geo. Lawley & Son Corporation, Neponset, Mass.

John M. McGrath, Marine Superintendent, American and Cuban Line, 27 William Street, New York, N. Y.

Christian Nielsen, Superintending Engineer, Lobnitz & Co., Shipbuilders and Engineers, 77 Broad Street, New York, N. Y.

John F. O'Neill, Marine Superintendent, of the Munson Steamship Line. Home, Flagstown, N. J.

Fred. O. Percy, Assistant Chief Hull Draughtsman, Fore River Shipbuilding Corporation, Quincy, Mass.

Carlo Pfister, Commander Royal Italian Navy, Italian Consulate, New York, N. Y.

Ernest Pulsford, Engineer in Charge, Marine Department, Lidgerwood Manufacturing Company, 96 Liberty Street, New York, N. Y.

R. Royal Roane, Engineer Vulcan Iron Works, Inc., Jersey City, N. J.

Ralph M. Roberg, Manager Sanderson & Porter Shipyards, Raymond, Wash.

Taylor W. Ross, Superintendent of Repairs and Docks, Newport News Shipbuilding and Drydock Company, Newport News, Va.

Elmer P. Rust, Lieutenant, U. S. N., Inspector of Machinery, C. H. Wheeler Manufacturing Company, Philadelphia; 4733 Marine Street, Philadelphia.

Albert E. Saunders, Naval Architect, Sun Shipbuilding Company, Chester, Pa.

John E. Schlegel, Chief Draughtsman, The New York Yacht Launch & Engine Co., Morris Heights, New York, N. Y.

S. Takaki, Naval Architect to Osaka Iron Works, Ltd., Sakurajima, Osaka, W., Japan.

George Warrington, Superintending Engineer U. S. Light House Service, 3311 16th Street, Washington, D. C.

E. B. Williams, Manager, Marine Department, B. F. Sturtevant Co., Hyde Park, Mass.

E. C. Williams, Ship Draughtsman, Mare Island Navy Yard, California.

Thomas H. Yeager, Lieutenant of Engineers, U. S. Coast Guard, Navy Department, Washington, D. C.

William J. Zimola, Mechanical Engineer, Fore River Shipbuilding Corporation, Quincy, Mass.

Arthur Bolton, Chief Draughtsman, Federal Shipbuilding Company, Newark, N. J.

Howard Fisher, Superintendent, Kensington Shipyard Department, Wm. Cramp & Sons, Philadelphia, Pa.

Svend H. Nyholm, Leading Draughtsman, Cox & Stevens, 15 William Street, New York, N. Y.

Norman W. Pevear, Draughtsman, Cox & Stevens, 15 William Street, New York, N. Y.

George N. Scott, Chief Engineer and Naval Architect, Standard Shipbuilding Company, Shooters' Island, S. I., N. Y.

Benjamin P. Young, Ship Surveyor, Cox & Stevens, 15 William Street, New York, N. Y.

John J. Dement, Assistant Superintendent, Robins Dry Dock and Repair Company, 43½ Dikeman Street, Brooklyn, N. Y.

James W. Hussey, Naval Architect, 200 South 12th Street, Philadelphia, Pa.

Alfred J. C. Robertson, Assistant to Naval Architect, Emergency Fleet Corporation, 3724 Jocelyn St., Washington, D. C.

Kyoji Suyehiro, Professor, Naval Architecture, Tokio Imperial University, Tokio, Japan.

Richard V. Cowley, Resident Inspector, U. S. Shipping Board, Savannah, Ga.

James Norman Craig, Assistant Chief Marine Engineer, Terry Shipbuilding Corporation, Savannah, Ga.

John McLean, Shipyard Superintendent, Terry Shipbuilding Corporation, Savannah, Ga.

Robert Crawford, Assistant Naval Architect, Terry Shipbuilding Corporation, Savannah, Ga.

Alexander Watt, Chief Marine Engineer, Terry Shipbuilding Corporation, Savannah, Ga.

Thomas Spencer, Surveyor, American Bureau of Shipping, 66 Beaver Street, New York, N. Y.

Harry Warburton Dobson, Draughtsman, Worthndyke, N. J.

Edward Isaac Evans, Surveyor, Lloyds Register of Shipping, Detroit, Mich.

Thomas Beall Richey, Assistant Naval Constructor, U. S. N., Navy Yard, Boston, Mass.

Geo. L. Kay, Surveyor, American Bureau of Shipping, Technical Staff, 66 Beaver Street, New York, N. Y.

Edward Granville Tuck, Surveyor, American Bureau of Shipping, 66 Beaver Street, New York, N. Y.

Harry L. Hunt, Surveyor, American Bureau of Shipping, 66 Beaver Street, New York, N. Y.

Joseph Wm. Richardson, President, D. M. Nichols Iron Works, New York, N. Y.

James Carson, Director and Secretary, La Parmentin Shipbuilding Corporation, 1482 Broadway, New York, N. Y.

Walter F. Alexander, Surveyor, American Bureau of Shipping, 66 Beaver Street, New York, N. Y.

James M. Roberts, Surveyor, American Bureau of Shipping, 66 Beaver Street, New York, N. Y.

Associates (25).

John de M. Crawford, U. S. Engineer Officer, 4th Mississippi River District for Mississippi River Company, Queen and Crescent Building, New Orleans, La.

Alvin H. King, Paymaster U. S. N., Accounting Officer, Navy Yard, Boston, Mass.

William Lambie, Chief Hull Draughtsman, Hollywood Shipyards, Inc., Oakland, Cal.

Walter J. McInnis, Chief Draughtsman, Geo. Lawley & Son Corporation, Neponset, Mass.

William C. Morehead, President and Managing Director, Great Lakes Boat Building Corporation, Milwaukee, Wis.

Joseph Nardini, Outside Manager, International Compositions Company, Inc., 18 Broadway, New York, N. Y.

John L. Perchick, Hull Draughtsman, Sun Shipbuilding Company, 2137 North 32d Street, Philadelphia, Pa.

F. J. Renz, Sales Manager, Federal Composition, 17 Battery Place, New York, N. Y.

William H. Ripley, Marine Sales Engineer, The Griscom-Russell Company, 90 West Street, New York, N. Y.

Rolf de Trentini, Hull Draughtsman, ForeRiver Shipbuilding Corporation, Quincy, Mass.

Henry D. Van Doorn, Manager, Marine Department, American Clay Machinery Company, 516 Liberty Building, Philadelphia, Pa.

Theobald P. Weber, Draughtsman, Geo. Lawley & Son Corporation, Neponset, Boston, Mass.

James Sefton Wellings, Jr., Draughtsman, Fore River Shipbuilding Corporation, Quincy, Mass.

Arthur C. Settan, Draughtsman, Cox & Stevens, 15 William Street, New York, N. Y.

Hin Yung Tu, Draughtsman, New York Shipbuilding Company, Camden, N. J.

Royce A. Beekman, Engineer, Marine Department, General Electric Company, Schenectady, N. Y.

Aaron Matheis, Draughtsman, Federal Shipbuilding Company, 54 Dey Street, New York, N. Y.

Moritz H. Jaehne, Hull Draughtsman, Bethlehem Shipbuilding Corporation, Union Plant.

Maury Polk Gregg, Surveyor, American Bureau of Shipping, Technical Staff, 66 Beaver Street, New York, N. Y.

Basil T. Stronnicof, Assistant Professor, Polytechnical Institute, Petrograd, Russia.

Ernest J. Lolmann, Draughtsman, Cox & Stevens, 15 William Street, New York, N. Y.

A. L. Kearns, President, A. L. Kearns Company, 2929 Broadway, New York, N. Y.

John C. Harland, General Manager, International Compositions Company, Inc., 18 Broadway, New York, N. Y.

Alfred B. Shafer, Vice-President, Puget Sound Machinery Depot, Seattle, Wash.

R. L. Thomsen, Marine Sales Engineer, Griscom Russell Company, 90 West Street, New York, N. Y.

Juniors (10).

Harold T. Bent, Inspector, Newport News Shipbuilding and Dry Dock Company, Newport News, Va.

Edward C. Elterich, Chief Draughtsman, Tank Shipbuilding Corporation, 120 Broadway, New York, N. Y.

Arthur W. Gunn, Hull Draughtsman, Lake Torpedo Boat Company, Bridgeport, Conn.

Richard D Karr, Draughtsman, Electric Boat Company, Quincy, Mass.

Edwin Overton Perkins, Hull Draughtsman, Union Iron Works, San Francisco, Cal.

De Witt C. Ramsay, Hull Draughtsman, Lake Torpedo Boat Company, Bridgeport, Conn.

George A. Andrews, Assistant Naval Constructor, U. S. Navy, Massachusetts Institute of Technology, Boston, Mass.

W. Neal Briceland, Draughtsman, Morse Dry Dock & Repair Company, Brooklyn, N. Y.

Edward G. Binder, Draughtsman, Terry Shipbuilding Corporation, Savannah, Ga.

Andrew Fletcher, Jr., Outside Superintendent and Director of The W. & A. Fletcher Company, Hoboken, N. J.

Associates to Members (3).

Carl A. Schafer, Assistant to Naval Architect, Sun Shipbuilding Company, Chester, Pa.

Sydney B. Carpenter, Vice-President and General Manager, Brunswick Refrigerating Company, New Brunswick, N. J.

Richard B. Cook, Chief Hull Draughtsman, Cox & Stevens, 15 William Street, New York, N. Y.

Junior to Member (1).

Frank A. Track, Naval Architect, Sanderson and Porter Shipyards, Raymond, Wash.

Junior to Associate (1).

Felipe Altamirano, Ship Draughtsman, Foundation Company, Aspen, N. J.

THE PRESIDENT:—I am sure it will be gratifying to the members of the Society to know that there is such a great interest now being taken in its affairs. I observe, gentlemen, that there are only two flags here at the back of the platform, the British and American flags. I can assure you, had I my way, there would have been a great many more flags there, as the flags of all the Allies should have been in this room. I trust they will be in the banquet room tomorrow night. If they can be obtained, they will be there.

The program now calls for the president's address. I was about to say I want to apologize, but I do not think that is the word. I want to explain to you, that owing to a near collapse due to overwork recently, I have not been able to prepare for you such a presidential address as I would like. I hope you will forgive the brevity of the address. That, however, is a good fault, but there is also a paucity of topics and an incompleteness in the address that is not at all satisfactory to me. If, however, you will read the matter carefully I think you can make deductions from it that will suit yourselves and you may perhaps draw from it certain things which I could not now say in a public address

PRESIDENT'S ADDRESS.

Just one year ago, in the president's address was given his summary of the conditions of shipping and shipbuilding throughout the world. The statistics then given were to his satisfaction and apparently were received with satisfaction by all parties interested.

Not only has much water passed under the bridges in that brief year, but great floods have passed and still are passing, throwing all of those calculations into the discard.

At that time, though there were many who thought our own beloved country should have previously entered into the world war, it really appeared as though we were to be free from any active participation. The renewal of ruthless submarine warfare last February made this impossible, and whether we should have been in the mêlée before or not is not a question for discussion before this Society.

It is sufficient that the United States of America has for good cause joined the Allies who are fighting the Central Nations of Europe, and one of the means to be used by this country is the building of many new ships in the old and in many new yards as well as the taking over of all ships previously under construction.

Your president, now a naval officer by one of the exigencies of war, is properly forbidden to give any information that may come to him by virtue of his commission. He has, however, no claim to any special information and in this address will use only statements that have been published in the public press presumably by authority. Like the poet with his nosegay, the flowers are culled with nothing of his own but the string that ties them.

Taken from last year's address, we find the total capacity per annum prior to 1916, of shipyards for building merchant vessels, to have been as follows:—

	Registered tonnage.
United Kingdom, Colonies and Canada	1,984,000
United States, including the Great Lakes	540,000
Germany and Austria-Hungary	527,000
All other countries	634,000
Total capacity per annum of the shipyards of the world	3,685,000

Notwithstanding the decrease in merchant shipbuilding in the United Kingdom and Germany caused by the necessities of war, owing to the increase in capacity of United States yards (about 100,000 tons) and elsewhere in the world (about 76,000 tons), the total production of merchant vessels in the shipyards of the world during this year 1917 will be approximately 3,250,000 tons, almost as much as during the banner year of 1913, when there were launched about 3,300,000 registered tons.

But there has been in this country a great change during this same year. In November, 1916, there were about 66 shipyards in the United States in 27 of which were built wood ships. At this time, November, 1917, there are about 142 shipyards in the United States, 59 of which are building wood vessels and 4 of which are building composite vessels. With the tremendous program of the U. S. Shipping Board, to which must be added the 787 new ships for our navy at a cost of $1,150,400,000, from dreadnoughts to submarine chasers—"making the navy the most powerful in the world, second to none," and the necessary additions to our shipyards to accomplish these feats, you may be sure there will be no idle days, but many busy days and nights for several years to come.

It is to be noted that the increase in the number of new wood shipyards is great, but the capacity of same is not nearly so great as the total capacity of the new steel shipyards. Whether after the completion of the many wood vessels now under contract for delivery in the next two years, there will be any demand for wood ships from these new yards is extremely doubtful because in normal times there is no question concerning the superiority of the steel ships.

The amount of destruction of vessels by German submarines is uncertain. British authorities give the net loss of British vessels over 1,600 tons, from the commencement of the war to October 31, this year, as 2,500,000 registered tons. Other authorities say that neutral nations, including the United States, have lost about 1,700,000 tons, making a total of 4,200,000 tons, which is probably too low—certainly much lower than claimed by the German government.

It is clear, however, that the special efforts of the naval vessels of the Allies have succeeded in keeping within control the destruction by submarines. British authority also states that between 40 and 50 per cent of the German submarines operating since the war commenced have been destroyed, but there is apparently no certain knowledge of the number of German submarines under construction.

The announced program of the United States Shipping Board, for a merchant marine at the end of the year 1919, shows a grand total of 14,500,000 dead-weight tons capacity, approximately 9,600,000 registered tonnage. This includes all new construction for their Emergency Fleet Corporation, all alien and United States ships under construction and commandeered and the enemy ships that have been seized within our ports.

To bring to a successful conclusion this program, and its successful operation as well, is a prodigious task, requiring all of the energy, enterprise, foresight and earnest activity for which American leaders are noted. That the board may be assisted in its desired accomplishment, the whole-hearted support of the members of this Society, a unit of men upon whom so much depends, must be given without limit of service or reserve of any sort.

In order that the successful operation of the contemplated enormous fleet may follow after the war, it will be necessary that some existing shipping laws be modified that the Shipping Board may be enabled to compete with all of the other nations, for doubtless following this war of force and destruction there will come a commercial war, a war of the flags upon the seas.

One of the great difficulties that faces everyone interested in the building of ships is that presented by the body of workers usually termed Labor. Now that every other effort than that which comes under this particular class is to all intents and purposes commandeered to do its utmost in behalf of the nation regardless of time and sacrifice, it is certainly reasonable to expect that labor shall at least be as efficient as possible and shall not take any undue advantage of the situation. That labor thus far has complied with this expectation cannot truly be said. The recent careful and eloquent address of President Wilson before the Buffalo Labor Convention may bring about a change much to be desired, indeed absolutely necessary.

The question has been asked many times, often by those as capable of judging as the speaker: When will this war be over?

He does not pretend to know, but he feels that the end is far off. Recent events in Russia and Italy surely tend to prolong the war because they serve to encourage the German government and particularly the German people, but they must not serve to discourage our Allies nor ourselves.

In the address of the acting president at our annual meeting in December, 1914, attention was called to those racial tendencies and desires for empire that keep alive the consecration and patriotism so clearly shown by the great nations of Europe.

The cause of this great war that has so upset the world may in many minds be in doubt, but the Germans, aided by their vassals, the Austrians and Hungarians, are fighting for a world supremacy which they claim for their national existence. There can be no doubt, however, in our minds as to the methods and acts of the Germans in the conduct of the war, methods and acts so conscienceless that they have forced most of the nations of the world to put them in the class of outlaws.

It is not necessary to here recount what these acts have been. The published statements of Secretary Lansing, Viscount Bryce, Dr. van Dyke, Minister Gerard, Hugh Gibson and many others who have all had exceptional opportunities for intimate knowledge thereof, clearly show the numberless violations of all laws hitherto governing nations at war; and no American with a drop of patriotic blood in his veins can wish that the United States should have done aught else than join the Allies in the fight for freedom of all nations from such arbitrary and ruthless militarism.

Setting aside the defection of Russia and the recent defeat of Italy, the effects of which we trust may be temporary, there still remains for us the splendid examples of France, Belgium and the United Kingdom in their consecration to ideals, while the enemy holds to vastly different ideas.

The enemy must not be underrated, for his whole course during the past three years has shown a preparation and an organization hitherto unequalled. The pity of it is that such preparation and organization have been used for such terrible ends. Nor must it be thought that the people of Germany are not supporting their government. Events have shown that their education has been so completely to this end, that the people themselves feel that the desires of their rulers must be accomplished regardless of all other nations. Were this not so, the German people would ere this have risen in revolt.

And so it has come to pass that the United States of America have joined the Allies, determined to fight out the issue to the end that the world may be safe from any similar war in the future.

What, then, will bring peace? So long as German territory is free from the awful destruction caused by the occupation of an enemy, just so long will the German people fail to

realize that they have not won and cannot win. Only the dire experience that will appeal more to them than even the loss of beloved ones will cause a change of heart and make known to them the wrongs that have been committed in their name.

So America with her wealth, her supreme efforts at home and abroad, and above all with her precious blood, free from taint of wishing for more territory, free from desire for indemnities, free from the grosser aspects of war, must with one heart, one mind, and one soul support the President of the United States in this crisis of the world.

The President:—Before we take up the reading of papers, I wish to call attention to the secretary's notice that the readers of papers are confined to fifteen minutes, and that they should read abstracts of the papers, rather than the full paper, where the papers are longer than can be confined within a period of fifteen minutes in their presentation.

The first paper on the program is No. 1, "The Service Department of a Shipyard," by Mr. Samuel W. Wakeman, Member. Mr. Wakeman could not be present, and I understand Mr. Larkin was to read this paper. Is he present? If not, the acting secretary will be kind enough to read the paper in the absence of the author.

Acting Secretary Carmichael then read the paper.

THE SERVICE DEPARTMENT OF A SHIPYARD.

By Samuel W. Wakeman, Esq., Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

The object of this paper is to describe a method of handling certain phases of shipyard work which has been successfully tried out in one large eastern plant.

Although some of the functions of this department are probably being carried out in the different yards to-day, we do not know of anyone who has treated this problem in just this manner.

About two years ago the president of the plant became interested in the enormous number of men that it was necessary to hire each month in order to maintain the working force then needed to carry out the work in hand. He determined that this problem must be solved and a committee was selected from the plant, composed of workmen, foremen and others. They made a tour of the country, visiting the following manufacturing concerns:—Link Belt Company, Sherwin Williams Company, Jeffery Manufacturing Company, Cleveland Hardware Company, Curtis Publishing Company, Chalmers Motor Company, Cleveland Foundry Company, Goodyear Tire and Rubber Company, Cadillac Motor Company, National Cash Register Company, Dodge Motor Company, Packard Motor Company, Ford Motor Company, Westinghouse Manufacturing Company, Carnegie Steel Company.

The most courteous treatment was accorded this committee at each of the above mentioned plants, and the fullest information was given by them on all of the points which the committee investigated.

On their return they prepared a report of their investigations, together with such recommendations as to the betterment of the then existing conditions as they thought should be made, these recommendations including such ideas as the centralizing of employment instead of allowing each one of the different department heads to carry this on themselves. It also recommended that a new building be erected for this purpose; that a different point of view be taken with regard to applicants for positions, namely, their treatment should be as courteous and as fair as was possible to be given; that the housing and boarding situation be investigated; that all men leaving the employ of the company should be interviewed and given a chance to air their grievances. They further recommended a great many lines of activities to be encouraged in the plant and touched on many lines that had to do with the physical, mental and social condition of the employees. The recommendations of this committee were printed in pamphlet form and sent to about two hundred people in the plant. They were asked to freely criticise and, if possible,

to make further recommendations. All of this information was then collected and formed the basis for the policy which is being pursued at the present time in regard to the service work in this plant.

A brick building was erected near the main gates of the plant to take care of the hospital work, the employment department, and the general activities of that nature. These activities were grouped under the name of Service Department which, as its name signifies, is to render service to the employees of the plant. This department was put under the supervision of the general superintendent of the plant. The scope of its activities are as follows:—Employment, hospital, safety work, educational work, apprentices, employees' club, works paper, suggestion committee work, yard restaurant, shop training.

The personnel of this department consists of the following:—Supervisor, assistant, clerks, stenographer, supervisor of instructors, instructors, employment agent, employment clerk, doorman, doctors, nurses, messenger boys for conducting applicants to shops.

In order to see clearly the relationship between the service department and the superintendents and foremen in the yard in regard to the supply of labor, the following illustration is used:—

The ship carpenter may want ten pieces of 12-inch by 12-inch yellow pine 30 feet long. His requisition comes to the purchasing agent, who buys this material and has the same delivered to the ship carpenter. If on inspection by him three or four pieces out of the ten prove defective, he condemns this material and the purchasing agent replaces it. The ship carpenter decides what class of work this lumber can be used for and decides also whether the price paid for it is justified.

The same procedure holds for the supply of labor. A foreman finds he will need a certain number of men at a given time. He sends his requisition for this labor to the employment division of the service department. They send the required number of men to the foreman after interviewing these men and weeding out, so far as is possible, such applicants as would be incapable of carrying out the work for which they are required. These men are sent to the foreman of the department, who takes or rejects whatever number he may see fit and rates those he keeps, and those he rejects are sent back to the employment department, where an effort is made to place them in some other department in the yard where they may find work which they can do.

If the men hired are not satisfactory to the foreman, he may discharge them. In no particular are any of the foreman's prerogatives in regard to the handling of labor taken from him. The advantage of this method, however, is that the foreman is not compelled to interview a large number of men who have no qualifications for the work he is supervising, and his time is conserved for the more important duties he has to perform.

Each applicant for a position is put through a careful physical examination by the company's doctor, and only such men are employed as are capable of doing the work for which they are hired. This has resulted in getting a very good class of

men, and, where slight physical defects are found which can easily be remedied, the man is sent to the proper medical authority and taken care of. At first there was considerable objection on the part of some of the men, but at the present time practically no one objects to the physical examination.

The employment department keeps an up-to-date requisition of all labor requirements of the plant, and takes such steps as are necessary, through its various sources of supply, to keep this requisition filled. It attempts to learn, by keeping in close touch with the various departments, the probable future needs for labor, which is a vitally essential factor in keeping a steady flow of men into the yard.

All applicants for work are quartered in a waiting room in the service building, equipped with chairs, and are interviewed in turn by the employment agent, being given a private interview in a separate room.

Each applicant when hired is given a book which contains all the information about the plant that it is considered a new man should have. This book has been carefully prepared and gives the hours of labor, the method of tool delivery, certain safety suggestions, times and methods of payment of wages and, in general, information in a condensed form which the new employee generally gets only after long association in the plant. This book has proven to be a great help to new men coming into the plant. All employees transferred or leaving the employ of the company are required to be interviewed by the employment agent before they can obtain their wages. This provides an opportunity to place the man in a department where he may fit to better advantage than the one in which he was working and also gives him opportunity to state any grievances he may have in connection with the company, his foreman or his work. These grievances are carefully tabulated and looked into and have been found to be a great source of valuable information in connection with controlling the feeling the employees have toward the company. All records for present and past employees are filed alphabetically in the employment bureau, and these records contain the name, age, trade, physical qualifications, address, place of past employment, rate, etc.

There is a daily report prepared by the employment department, showing the number of men hired and leaving by trades, also daily gain or loss in the working force. The department also makes a monthly report of the turnover of labor, including the number of men hired and leaving by trades, showing the length of service and reasons for the man leaving.

One of the most important phases of the employment work is to provide proper housing facilities, and to this end the employment department lists, for the information of all applicants, boarding houses and available houses for sale or for rent.

If there is no position open at the time the applicant applies in person or by letter, an application card is filled out and filed by trades. All applications for employment are filed and, as far as possible, the applicant is informed as to what date his services will be required, giving the minimum and maximum rate for the trade desired and the hours of labor.

Under the service department is a competent surgeon and an up-to-date hospital where all of the accident cases in the yard are treated. The families of the employees may obtain free medical attention during certain hours of the day.

The safety work in the plant, which had reached a fair state of development, was combined with the work of the service department, and the different shop committees, together with the General Safety Committee, use this building as a meeting place where frequent talks by men who are specialists along this line of work are given to these men. Each department has its own safety committee, which makes periodical inspections and reports directly to the General Safety Committee. A great many ideas for work of this nature have originated in these committees and numerous appliances and safeguards have been adopted, due to suggestions received from them. All accidents are carefully investigated and the causes are immediately remedied; responsibility for accidents, as far as possible, is placed and steps taken to rectify them.

All of the educational work in connection with the training of apprentices and the training of men in the shops and different departments throughout the yard have been placed under the jurisdiction of the service department.

During the winter months, evening schools are conducted which provide training in naval architecture, mold-loft work, plumbing, coppersmith work, machine shop design, mathematics and blueprint reading. The instructors for these evening classes are, for the most part, drawn from the various departments in the yard and the instructions carried out under the direction of the local school board. These classes are open to any male beyond the age of sixteen in this locality and are attended by mechanics, apprentices, and helpers to the number of about two hundred.

All of the work in connection with the apprentices in the plant is carried out under the supervision of the foremen in the different departments, but along the lines as laid down by the educational part of the service department, and the head of this department has been very successful in this connection with the attitude of the apprentice toward the company. Each year a dinner, to which prominent officials of the company are invited, is given by the apprentices, and efforts are made to promote the best of feeling among the young men who are being trained for future service in the company.

The service department supervises the publication of a works paper, which is issued every three months by the employees. This paper has developed to such an extent that its issue is awaited with a great deal of interest by all of the men in the plant.

The company presented to the employees of the plant a club house equipped with bowling alleys, rifle range, assembly and dancing hall, pool table, a band room and an athletic field where the different athletic teams practice and have their games. Quarters are provided for the athletic teams of the company in this building with suitable shower-baths, etc. This club is run entirely by the employees of the company, and only such necessary supervision is given to it by the service department as is absolutely necessary.

A restaurant is maintained inside the plant for the benefit of the employees. The supervision of this restaurant, although run by an outside caterer, is left to a committee of the employees who are in close touch with the service department.

One very important part of this service department work is the handling of the suggestions sent in by employees. Boxes are placed throughout the yard and prizes are offered for suggestions sent in by the men. There is a great deal of work in connection with the proper understanding of what the employee means, the making of sketches, the referring of these suggestions to the proper people so that they may be acted on, and the attitude which the men have toward this phase of the work must be carefully handled in order that the greatest amount of good may come from it. The work of this committee, of which the head of the service department is chairman, is one of the very important functions of this department.

All of this work has begun to show results which it is felt can directly be traced to the work of this department. Statistics for many of the large manufacturing plants throughout the country that have attempted to increase their working force have shown that it is necessary to hire anywhere from seven to ten men in order to obtain one permanent employee. The latest results here have shown that it has been necessary to hire two men instead of from seven to ten in order to obtain one. When you consider that it is estimated that it costs somewhere between $20 and $35 to hire a new employee the result of cutting down the turnover in any plant means a tremendous saving in dollars and cents, although it may not always be possible to directly measure this.

Much of the reason for this decrease in turnover can be credited to the selection on the part of the service department; the hearty cooperation of the foremen, who have allowed a very liberal system of transfer from one department to another; the training of men into trades which they were not familiar with and, in the main, to the general broad policy of the man directing the company.

Before the above plan was in operation, in order to maintain a force of about 4,000 employees it was found necessary to hire, in the course of a year, 8,000 men. During the last six months the present force has been increased from 4,000 to 8,000, and this has been done by hiring 9,000 men. While these results cannot all be attributed to the work of this department, nevertheless it is felt that, in a large measure, the work which has been accomplished by them is responsible for a large percentage of this showing.

It is not claimed that any new or radical ideas have been adopted in connection with the handling of this situation, but what has been done is to find out what successful concerns in other lines of work have done and to combine them together in such a way that they might be adapted to the work of a shipyard.

A man was employed who was thoroughly familiar with the sources of labor supply in the district in which this plant is located, and much credit is due him for the enthusiasm with which he approached this difficult problem.

An outline diagram showing the relationship of the different functions of this department to each other is attached and made a part of this paper.

- **Head of Service Department.**
  - Employment Agent
    - Interviewing and hiring new employees.
    - Recruiting labor outside the plant.
  - Correspondence Clerk
    - Housing new employees.
    - Interviewing and recording departing employees.
  - Messengers (3)
    - Monthly analysis of employees hired and departed.
  - Recording Clerk
    - Recording on cards new employees.
    - Daily report of men hired.
  - Door Man
    - Filing record cards of new employees.
    - Charge of main waiting room.
  - Assistant Stenographer 2 Clerks
    - Employees' Magazine
      - Associate editors.
      - Collection, compilation, proofreading, publication and distribution.
    - Safety Work
      - Monthly statement of hours lost and percentage; accidents; recommendations approved; by General Safety Committee
      - Investigating and reporting special cases, bulletin posting.
      - Shop committees, organization and reporting.
      - General Safety Committee minutes.
    - Apprentices
      - Applications, tools, bonuses, and certificates.
      - Shop credit reports.
      - General welfare, social activities, etc.
      - Book apprentices time and quarterly reports.
    - Employees' Club
      - Minutes of meetings.
      - Publicity of activities.
      - Membership and dues.
      - Athletic activities.
    - General
      - Circulation of monthly periodicals.
      - Restaurant committee, supervision of yard restaurant.
      - Arrangement bulletin boards.
      - Naturalization assistance.
      - Navy League, rifle company.
      - Assistance to employees in promoting outings.
      - Information of any kind to employees.
    - Educational
      - Keep records of attendance.
      - Outline of curriculum.
      - Receive applicants for classes.
    - Housing
      - Listing of lodging and rooming houses available for new men.
      - Information regarding houses for sale and to rent.
      - Advice to employees wishing to buy houses.
    - Suggestion Committee
      - Receipt and referring of suggestions to parties directly concerned.
      - After receipt of comments, action upon same by committee.
      - Recommendation of an award.
      - Notification to sender.

DISCUSSION.

THE PRESIDENT:—This paper, entitled "The Service Department of a Shipyard," is now before you, gentlemen, for discussion. We will be very glad to hear any member or any person present discuss this paper.

NAVAL CONSTRUCTOR T. G. ROBERTS, *Member:*—I suppose I ought to be the first to discuss this paper, as until recently I have spent four years at the Fore River Shipbuilding Company's plant and have been familiar with it before the advent of this service and after.

This, I think, is perhaps the first note of work of this character which has appeared in the literature of this Society. This matter has been dealt with in the literature of the subject under the heading of "Welfare Work." The term itself has become a little unpopular, because it did not seem to cover the whole field, and now they are trying to change it. *Industrial Management* calls it "industrial betterment" or "betterment work." The Fore River Shipbuilding Company calls it the "Service Department," and I see that term has been carried by one of the men who has been associated with the Fore River Company in this work, Mr. Meyer Bloomfield, who is one of the editors of *Industrial Management.* He has been recently acquired by the U. S. Shipping Board and is now the head of their service department. He has furthered this work and extended it now to the other shipyards. He had largely to do with placing the Fore River Company in touch with the large sources of labor that are available in New England, and since the beginning of the Shipping Board he has extended this work, as I know that there was a conference of shipbuilders in Boston recently where I represented the Navy Department, and the object of that meeting was to extend this work to the shipyards throughout the country—certain phases of it, the phases that they needed most, especially the training of workmen.

Mr. Meyer Bloomfield, in assisting the Fore River Company, did not start this work. It was done, I think, under Mr. Larkin, who is referred to here as the head of this department, but between them and among them they got in touch with the labor bureaus which have been recently established by the new Department of Labor, the idea being to connect the idle worker with the job. There are also bureaus representing the state employment offices, either in Boston or in the various cities in New England, and also city employment offices; and there is also the Y. M. C. A. in cities like Washington, Boston, Providence, New York, and the various vocational schools, of which there are numbers throughout New England.

I know that this shipbuilding company was placed in touch with all of these sources of labor, and I have been reliably informed that they were able to obtain labor with great facility as compared with other places in the country, and am quite sure, from the information at hand, that it had something to do with the distribution of contracts for ships and the ability of the shipbuilders to undertake to turn out a comparatively great volume of shipping.

This is a new feature in shipyards, looking into the question of the human element, to care for the wants of the workmen and to animate the good-will and enthusiasm of the

workers, which latter day management seems to find out is a paying proposition, aside from the betterment of the workman himself, and also a paying proposition from the standpoint of the public at large.

In fact, it has come to be recognized now in industry that the largest element in management is the human element, and that in order to have the workman to work to the best advantage he must work with a good will, with good health, under the best conditions, and in happiness. The question of organization comes after that, for producing mechanisms that go towards coordinating the efforts of the workmen and the building up of technical services; but these are subsidiary to the first element—the welfare of the men.

Naval Constructor Richard M. Watt, *Vice-President*:—I feel that the thanks of the Society are due the author of this paper for presenting in such detail the procedure of the service department of a large shipyard. The question of so handling labor as to secure its loyalty and cooperation is the greatest problem with which managers are concerned.

I was particularly impressed by one point in the paper, namely, the idea of the pamphlet giving the new man complete information about the plant which a new man should have. While some new employees will throw this pamphlet away, many will study it carefully and will be sooner prepared to do their full parts in the success of the shipyard.

That the service department is operating successfully is abundantly proven, to my mind, by a sentence on page 5, which says that the foremen have allowed a very liberal system of transfer from one department to another, because I have found that the general attitude of a foreman is that, when a man fails to give him satisfaction, the foreman will not endorse him for employment in any other shop.

I certainly feel that the thanks of the Society are due to Mr. Wakeman for this very interesting paper.

The President:—Does anyone else care to add to this discussion?

Assistant Naval Constructor A. W. Carmichael, *Member*:—Speaking of the labor around New York City, the problem is a great deal more difficult than it is almost in any other locality along this coast, so far as I know, for the reason that there is such an element of uneducated and very ignorant foreign workers to whom kind treatment does not appeal, so that the extension of this welfare work to the shipyards around Greater New York will meet with a great deal more objection than it will in some of the other yards.

Mr. S. W. Wakeman (Communicated):—I should like to add one thing as a matter of record, and that is to emphasize the point which was brought out in the discussion by Naval Constructor Roberts.

There should be no attempt made in the establishment of a department of this kind to inject the idea of doing welfare work for the employees. The department described is, as its name implies, a service department; namely, to be of service first to the employees of the plant and, secondly, to be of service to the company. If this department fails in either function, it is not a successful department.

The President:—Does anyone else wish to speak upon this question? This paper certainly shows the complexity of our whole life at the present time, and how it grows, out of which will come the simplicity that will aid in general efficiency.

With your permission I will, on your behalf, extend to Mr. Wakeman the thanks of the Society for the admirable paper which he has submitted.

We will now proceed to the next paper, No. 2, "Shipbuilding in the Gulf States and the Natural Resources and Facilities Favorable Thereto," by Mr. Charles N. Crowell, a member of the Society. As Mr. Crowell is not able to be present, Acting Secretary Carmichael will be kind enough to give an abstract of the paper.

The Acting Secretary read the abstract of the paper.

SHIPBUILDING IN THE GULF STATES AND THE NATURAL RESOURCES AND FACILITIES FAVORABLE THERETO.

By Charles N. Crowell, Esq., Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

The writer of this paper has for years been interested in the great natural resources and facilities favorable to shipbuilding in the Gulf states.

It was when the United States Shipping Board asked for 1,000 wooden ships that the idea at once presented itself—how large a quota of this could be supplied from this southern country? The Pacific coast can, of course, well do its share. The Atlantic states, however, are entirely dependent on the south for this timber supply.

As to the 1,000 ships, in the writer's opinion, that is not an impossible proposition —it depends on proper organization and a reasonable period of time.

The yellow pine timber supply of the south is furnished principally from the states of Mississippi, Louisiana and Texas. Of course, other states furnish a certain proportion, but the best of all is from Louisiana and the best of Louisiana is from Calcasieu Parish. The Calcasieu long leaf is the best shipbuilding timber in the world and the supply of that, taken in connection with what is furnished from adjacent parishes and counties, is sufficient to meet all reasonable demands for years to come.

In riding through this territory over the lines of the Iron Mountain, Santa Fe, Kansas City Southern and other roads, one passes through hundreds of saw-mill towns and thousands of acres of virgin pine; and in the river bottoms, Sabine, Neches, Trinity and Brazos, large forests of hardwood are available, containing the oak timber for vessel framing.

The writer has ridden by team through oak forests in north Louisiana twenty to thirty miles across, on which stood millions of feet of the finest oak timber. This is the supply and close at hand to the builder in the Gulf states, with the advantage of quick delivery and low freight rates.

And not only is this true of vessels of wood, but the facilities for building steel ships are also available. In east Texas, in the region adjacent to Beaumont, there are very extensive areas of iron ore. Plans are already being formed to develop this ore and will probably be put in shape in the near future. Smelters and rolling mills and fabricating plants will be established and steel ships will be a product of the south. As it is now, several contractors are considering the importation of fabricated steel with which to build steel and composite ships. This supply would come from Birmingham, Memphis and St. Louis. The important factor, fuel oil, is found all through Texas and Louisiana, as is well known.

The shipyards of the north, from Maine to Virginia, have, of course, many long-established plants, and history has told us of the days when American built wooden ships, masterpieces of the great designers, George Steers, Donald Mackay, William H. Webb and many others, were unexcelled on the high seas.

Answering to the great unprecedented demand for tonnage, all these plants—all regular shipyards—were naturally soon filled with orders. It remained to seek further for places to build and the response has been generous. Shipbuilding plants have sprung up all over the south; many there are which six months ago were covered with forest growth. The trees were cut and stumps removed by dredge boats and the suction dredge raised the grade to the desired height. Many of these plants to-day are well equipped, containing all modern labor-saving machinery and, in the district lying west of the Mississippi River, at least 150 vessels are building and contracted for.

Some of our northern plants may well profit by what is being done in the south. The facilities which they are introducing will insure rapid and economical work. Some of the men who are operating the various new shipyards have never built vessels, but, what is more important, they are men of executive ability, who know how to make up an efficient organization.

These same men, some of them entirely without shipbuilding experience, have gone ahead, taken contracts, selected their sites, cut off the trees, graded their yards and installed equipments, chosen their department heads and are building ships and building them well—as economically as many old-established plants which have been building ships for years.

One yard in Texas is to-day building fourteen wooden steamships, 4,700 tons dead weight capacity, completely equipped with machinery and everything ready for sea. So far as I know, these are the largest wooden ships in the world, in fact, the largest ever built. And there are four other yards in this same town, ideal ship sites.

Much has been said of building ships of green timber. In all the writer's experience, never has he seen a vessel built of any other except in the case of small craft, such as launches or in the selection of decking and planking more or less seasoned. The timbers and framing of a ship are generally cut to order and not carried in lumber yard stock.

Summarizing—the south not only has the material supply but she has it close at hand; already many building plants are well established and there are available sites for many more. Any kind of a ship and any integral part of a ship may be produced in this southern country.

And the men here are capable of producing satisfactory results. In these days of improved wood-working machinery, the skill of the shipwright, once the autocrat of his trade, is largely supplemented and compressed air now does most of the work of fastening, which forms a large percentage of shipyard work.

There is in these days no more of that heavy lifting common to olden times when it was customary to summon, "All hands to raise frame," or carry a 40-foot

oak deck beam on men's shoulders up the brow stage of a three-deck ship. The wooden shipyard crane or derrick does all that, making a saving in time and money.

Another advantage of this southern country is the small percentage of time lost. The winter climate is delightful and the summers, while they are longer, really do not attain to much higher temperature than is reached in New York City.

There is one shipyard starting in Morgan City, Louisiana, on the banks of the Atchafalaya River, 82 miles west of New Orleans. This is a beautiful location with a natural sloping grade, just right for a shipyard. Three months ago this was a sugar-cane plantation.

A bridge-building concern came along, saw the place, secured a contract for six 300-foot wooden steamships, and to-day that cane-field has been changed into a modern, well-equipped shipbuilding plant.

The young bridge engineer—he never built a vessel—has accomplished results which old builders would be proud of. Ways are built on complete pile foundations; traveling overhead cranes, his own invention, convey material from end to end of his vessels.

There are railroad tracks on both sides of every ship, locomotives and flat cars, locomotive cranes, three separate compressed air units, warehouses, mold loft, sheds for machinery, toolhouses, houses for the use of workmen at luncheon time; a complete system of water mains for fire protection; office building, containing every convenience even to the first-aid locker and, above all, plenty of room to properly segregate the material, the lumber which is arriving by millions of feet, thus at once avoiding unnecessary handling and properly storing that which will not be needed for awhile.

Nothing seems to be forgotten and never have we seen greater efficiency displayed or a better equipped wooden shipyard—and this man never built a ship. He is an engineer, and one who will succeed.

Speaking of oak ship frames, it has been the custom for years for Maine builders to bring their moulds, or patterns, down to the oak forests of Maryland and Virginia and hew out oak frames, keels, stems and sterns, thereby obtaining natural crooks, which greatly strengthen a vessel.

This is still being done, although the forests of the eastern states are well-nigh exhausted. But the south can supply these oak frames for many years yet.

While much yellow pine is used for framing, the necessary wide flitch timbers are cross-grained and afford but little strength; however, in this time of need, all sources of supply must be requisitioned, oak and pine, wood and steel.

All kinds of ships will be needed. No one will dispute the fact that a steel ship is superior—that is self-evident. But the point is this—build all the steel ships we can, build all the wooden ships possible. Build with experienced, old established yards, build from any reliable source. Build them everywhere and prove to the world that the American Merchant Marine is a thing that will be.

The Stars and Stripes, so little known in foreign parts of late years, should be

seen in every port in the world—and, as often, why should not America, as great as any nation on this earth, send her ships to every port? Why should foreigners carry our commerce? If any of our laws are prohibitive of such results, repeal them. Make the desired production possible of attainment. Our national, or natural, resources are second to none, and why should we lag behind in the great business game?

We must look beyond this present unfortunate state of war to a prosperous future, and commerce on the high seas—international and coastal, is the greatest factor in prosperity.

It has been said that so many wooden vessels being built now will be practically useless should the present war terminate and peace be declared—these wooden vessels could not compete with foreign steel freighters. Probably they could not, but they are necessary at the present time and can be used afterwards as coasting vessels and to carry freight to Central and South American ports.

At this time the number of ships possible of production is the vital question and the southern states can and will produce their quota. From Tampa to Corpus Christi our people are striving to do their part.

It is astonishing to see the evidences of patriotism underlying every undertaking—a love of country which will never admit of failure. Private contracts are being curtailed; every effort is being concentrated to build the thousand ships. From the man who goes into the woods with axe and saw to the master who takes command of the finished vessel, all have one great object in view—shipbuilding—and not only is this southern country building her quota but she is still soliciting more and is supplying the material to build ships to her neighbors in the north and east.

These great saw-mills, some of them with daily productions running into the hundreds of thousands of feet; gangs of men with broadaxes hewing out the splendid oak trees; shipyard organizations formed and forming, assembling the timbers; machinery men, preparing and installing boilers and engines; pine forests and shipyard sites, foundries and machine shops and capable men to operate; all this is available. This is the South.

DISCUSSION.

The President:—Now, gentlemen, there is a field for discussion; if not discussion, at least comment. For one, I certainly hope the sugar cane plantation will not be turned into a shipyard, much as we want ships, for I am very fond of sugar. Is there no comment on this paper?

There is one yard—I think it must be the same yard that is referred to here—that is producing wooden ships as good as any that were ever built in this country, and it is because

they are very carefully observing the faying of surfaces and the fitting together of frames, ceiling, planking and other parts. One fear that old shipbuilders have in the production of such large quantities of wooden ships by those who have never constructed ships before is the fact that they may in their ignorance, or if not in their ignorance in their hurry to finish the ship, pay very little attention to the fitting together of the parts.

Next to that are the fastenings with which, I fear, many of these men have not been familiar, and it will require considerable supervision to produce the desired result.

It certainly is very interesting to find in this paper that so much can be done down in the South. It only goes to show that out of war sometimes great advantages come to nations, and if there can be a development of this sort in the South, it would be of very great advantaye to the whole nation.

Mr. John F. Wentworth, *Member* (Communicated):—I am much interested in this paper on account of one statement made by the author. This statement is: "The young engineer—he never built a vessel—has accomplished results which older members would be proud of."

At the present time far too many bridge builders and the like have been put in charge of ship construction. One thing is certain, the United States Navy Department feels it is necessary to educate and train men to specialize in ship construction. If this policy of training specialists is wise, then it is questionable to put an untrained man in charge of ship construction. If this selection of a bridge builder as a ship builder is wise, then our system of specialized technical training is wrong.

This is a minor point in connection with this paper, but it is a point of great national importance in regard to our shipbuilding program. Inexperienced men are wasteful of time, material and labor, all of which are of vital importance at this time. The sentiment expressed in this paper is not uncommon. In one establishment the writer knows of, trained men familiar with ship construction have been overlooked and men from other branches of engineering have been brought in to direct operations with which they were unfamiliar.

At a time like the present, with our great need for good work and quick results, men with a special training should be put in the supervisory places. If this is not good judgment, then our system by which the present force of ship draughtsmen was developed should be abolished, or the product of this system should be used exclusively for railroad construction, mining, insurance engineering and other non-allied lines.

Mr. Charles N. Crowell, *Member* (Communicated):—It would seem from the general tenor of the remarks made on this subject, that a very slight conception exists in some sections of the extent of the work being done in these Southern shipyards.

The shipyards established here are unexcelled anywhere in any wooden yard in the East. The personnel of the organizations is equal to the best of them. The ships are being built as well and as quickly as they are in other sections—as a matter of fact, they probably excel some of the older yards.

Because a contractor is a bridge builder, or has been, we see no reason why he should not be a good shipbuilder. If he has the proper executive ability to organize his forces, and select the best shipbuilders in the country as his leaders, we see no reason why he should not be privileged to use this ability to the country's good. All this talk about inexperienced builders wasting time and material and doing poor work is rot. We have for years worked at ship-

building in many of the big Eastern yards, and we see but little difference except that our people are avoiding many of the errors made and profiting by later experience. In our many years of experience, we have never seen a better equipped wooden yard than that which has been built by our young bridge builder, over whom there seemed to be centered so much comment.

This builder is turning out six as fine ships as can be built anywhere. He employs good, experienced shipwrights, and is accomplishing more, with less waste of time and material, in a few months' time than has been done in many older yards in a much greater length of time.

In this Southern country, the timber is found close at hand. The climate admits of work every day in the year. This district is ahead in ship production now, and the ships are well built. Not only this, but these shipyards are permanent industries, and Bath will have to look well to her laurels, or the South will continue to hold the lead which she already possesses, both as to quantity and quality of shipping furnished to the country.

We are building 63 wooden ships between the Mississippi and the Rio Grande; twelve of them are 4,700 tons dead weight capacity—the largest wooden ships ever built, and we turned out one in six months' time. We are framing the square frame portion of the vessel in three days' time. Can any of our Eastern friends beat that record?

As to the quality of the work done, it is satisfactory to Lloyd's. The contractor building these boats actually uses over 100,000 feet of timber per day. Show us a yard in New York or Maine which is doing more than this. We are building ships in the South—with all other parts of the country, we are responding to the country's call for ships, and we naturally object to the rather narrow views reflecting upon inexperience and incompetency, which seemed to be the essence of comment on our paper.

As to the training of men referred to by one member, the whole system of so-called training seems to be centered on steel shipbuilding. We have failed to see in any case where any source of training exists for the benefit of the builder of wooden vessels.

The President:—If there is no further comment, I will, on your behalf, extend to the author the thanks of the Society for the admirable presentation of his subject.

The next paper, No. 3, is entitled, "Progress of Marine Engineering and the Education of the Marine Engineer," by Mr. Robert Haig, a member of the Society. We regret that Mr. Haig is also absent, and the Acting Secretary will present the paper in abstract only.

The Acting Secretary presented the paper.

PROGRESS OF MARINE ENGINEERING AND THE EDUCATION OF THE MARINE ENGINEER.

By Robert Haig, Esq., Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

In view of the increasing powers and details of marine engineering of the present day, does it call for a more highly trained seagoing engineer in the mercantile marine?

Investigation on this subject divides itself into two separate but closely related considerations, the development of types and increased powers in marine engineering, and the education and training of the engineer to fit him for his position.

It is not proposed to make this a close analysis of marine engineering growth, but rather to show in a general way the progressive steps and changes resulting in the various types of marine engines and auxiliaries to be found in vessels at the present time.

Dealing with this subject in the order set down, a brief review of the past twenty-five years to date will show that the changes have been, excepting perhaps the advent of the screw propeller, the most momentous in the annals of marine engineering. The most important departures have been the successful introduction of the direct and geared steam turbines, the electric direct drive, internal combustion engines, forced draft, and oil fuel.

Before dealing with either of the above notable changes, it would be instructive to consider what were the conditions prevailing at the beginning of the period under review. The usual types of engines then in use were three-cylinder triples, and, in the case of some large passenger vessels, a number of four-cylinder triples were at work with pressures ranging from 160 to 180 pounds per square inch. In some comparatively few cases quadruple engines with pressures of 215 pounds were at work and giving good results, and in the case of one firm five crank engines with pressures of 250 pounds had been turned out, but owners were still skeptical of the prospective advantages of the higher pressures and economy for power developed, when they had to consider the increased machinery space, weight and cost involved.

The ordinary reciprocating three-cylinder triple, like its predecessor, the two-cylinder compound, had given good results, but engineers kept reaching out and successfully so, where higher powers were demanded, for a more highly developed machine, which the quadruple with its higher pressures and greater number of expansions made a step nearer, and now within more recent years with extremely

high powers, in some cases in excess of 70,000 indicated horse-power the turbine direct-drive has become the prime mover. This for a time was followed for lesser powers and with very satisfactory results by the combinations of reciprocating and turbine engines working on separate shafts; and later by the single and double reduction geared turbines which are now having such remarkable developments, the arrangement giving a high-speed turbine of say 3,600 revolutions per minute, with a propeller speed of 70 revolutions per minute, which should produce ideal possibilities of steam efficiency and economy over a wide range of powers. The development of the double reduction gears means smaller and more compact units with lessened cost of installation and equally increased facilities in handling, but the greatest gain will be in the reduction of machinery weights which will be of especial value in high-speed, shallow-draught vessels where machinery weight saved has proven a positive gain in speed.

The mechanical efficiency and lasting qualities of gears may raise a question of doubt in some minds, and there have been some failures of gears, but the high class alloy steels that are now in use, combined with the splendid accuracy with which these gears are made, produce a gear for which a very high efficiency is claimed.

The most recent departures, however, for marine powers are so entirely disassociated from our previous experiences that we seem now to be on the threshold of a new era.

The electric direct drive has aroused the very greatest interest and able papers on the subject have been presented to this Society. So far, however, this type of power has been confined mostly, if not altogether, to government ships, and the very highest credit is due to those who are responsible to the Secretary of the United States Navy for their courage in advising this method of propulsive power for the Navy and its useful auxiliaries, as the undoubted possibilities of developing the power through high-speed turbines coupled to electric generators are fully recognized, and so far, from the performances reported, it would appear to have done all that was expected.

The real test of the suitability of the electric drive will be its capacity to withstand hard, continuous use for long periods, and there does not appear to be any substantial reason why this condition could not be met.

The question of economy and preference for this type of power will be largely determined by the measure of success attained in the efficiency of the mechanical construction and arrangement. The principle embodied is sound and should prove in time to have a wide field, but shipowners will be slow to endorse this type for merchant ships until they are assured of its practicability, and, what is equally important, that it will not entail a duplication of staff in the engine-room.

The internal-combustion engine, as represented by the Diesel and other types, has engaged considerable attention with various measures of success. In some notable cases, builders have had almost uniform success, while in others the results have been very costly and disappointing.

The principle of the various internal-combustion engines follows very closely upon the same broad lines whether they are two or four cycle engines, the main idea in each type is almost identical, but in the detail and mechanical construction the greatest divergence appears.

In many cases the whole design is unscientific to the last degree, and, if the same engine were adopted for steam, no doubt its performance would be equally bad. When the same broad principles underlying the present reciprocating engine are embodied in the internal-combustion engine, with due allowances for the enormous back pressures, cooling of cylinders, rods, scavenging, etc., then will be shown the success we have a right to expect.

The internal-combustion engine has at a very interesting stage of its growth suffered from the war conditions now prevailing, but from the information accumulated up to the present there does not seem to be a question of its success, if properly designed and built on sound principles; but it seems equally true that its adoption will be confined to a very large extent to powers not in excess of 2,000 shaft horse-power per shaft. This, of course, after all will take in most of the freight ships, which should prove a wide field, as the prevailing powers in the present-day freighter are from 2,500 to 3,500 indicated horse-power.

So far we have only passed in a general review the main driving power, which in the period of the compound and the earlier triple reciprocating engine had little more in addition than an independent ballast and auxiliary feed donkey, as in most cases the other pumps, feed, bilge, air and circulating pumps were all operated by the pump levers on the main engines. With each successive increase in power, pressure and change of type an elaboration of auxiliaries has developed, until at the present time we have a most extensive array of independent machines, the idea being to develop the whole of the main power through the propeller, leaving the feed, circulator, air pumps, etc., to be handled by independent units. In the case of the turbine engine this could not well be otherwise, even if it were desirable, and engineers have found in a multiplication of independent units that their responsibilities have increased to an extent that is rarely fully appreciated.

When we consider the mass of auxiliary machinery found on the present liners, all under the care of the engineering staff, and that upon the efficient performance of a large percentage of these machines the success of the whole outfit depends, it can be appreciated just how great are the responsibilities and how vital it is that they should be intelligently handled.

To briefly enumerate some of the auxiliaries usually found in vessels of high or even moderate powers of the present day, we find:—

Independent main and auxiliary feed pumps for main boilers.
Independent auxiliary feed pumps for donkey boilers.
Independent air pumps for main and auxiliary condensers.
Independent circulating pumps for main and auxiliary condensers.
Independent bilge, ballast, fire and sanitary pumps.
Independent feed heaters, evaporators and distillers.

Forced lubrication.
Grease extractors.
Boiler circulators.
Forced draft engines or motors.
Ash hoists or expellers.

Electric generators, for lighting and power, also motors, switchboards, ventilating systems; and if oil fuel is used, we have oil heaters, oil pressure pumps, oil transfer pumps, oil settling tanks, etc.

In the case of the internal-combustion engine, while some of the auxiliaries enumerated above would not be required, we would have others in their place, as the vessels fitted with internal-combustion engines have quite as extensive an auxiliary complement as the steam-engine of equal power, and a very much greater extended main engine to keep in order for the power developed.

The introduction of oil as a fuel dates back a very long time, its general use in the Caspian Sea on small Russian ships being established long before it was even considered feasible for ocean-going ships. The earlier installations were very elementary and the fuel used was crude oil and later some coarse distillate. The fuel at that period was looked upon as almost valueless and was in many cases running to waste, consequently there was no necessity to furnish anything better than the simplest and crudest types of burner as economy did not figure.

The fuel in a cold, thick condition was fed by gravity from settling tanks into the furnace, and attempts were made to vaporize it by steam pressure. As the possibilities of oil as a fuel became interesting and the supply assured, energetic steps were taken to develop, on a higher plane, burners and the whole oil fuel installation. One of the earliest firms to fit their vessels to burn oil fuel on a large scale was the Shell Line of London. They installed the Flannery Boyd system, which was brought out by the Wallsend Slipway Company of Wallsend-on-Tyne, England.

The principal feature of this system was that the double bottom and peaks were utilized for carrying the fuel, settling tanks being fitted at the level of the main deck in or adjacent to the forward end of the stokehold. The oil was pumped from the double bottom up into the settling tanks and fed by gravity to the burners. Coils were placed in the settling tanks for heating the oil.

For a time steam was used as the agent for vaporizing or splitting up the fuel into a fine spray as it left the burner. The use of steam for this purpose necessitated increased evaporators for make up feed, as, of course, the steam used could not be recovered. Considerable success was obtained by this method, and many ships were so fitted. Later steam as a vaporizing agent was discarded and heated air used with improved economy, other conditions remaining almost the same.

As the properties of oil as a fuel became better known, and more scientific methods of getting the full values were introduced, mechanical atomization of the oil came to the front, and to-day we have a number of thoroughly sound methods of burning oil fuel such as the Dahl, Peabody and White. One of the greatest

features of oil as a fuel is its flexibility; it can be forced to its maximum or reduced to its minimum at will. It admits of easy stowage and can be cleanly and quickly stowed. Very high efficiencies have been obtained by some installations, also remarkable results in the quantity of oil burned per square foot of grate. Its use means regular steaming and also minimizes the drawbacks of the human element in the stokehold.

The other side of the picture, however, is that oil fuel in unskilful hands can become almost a menace, as it can be forced to the limit in the endeavor to get more out of the boilers, and the very fact that it can in a moment be cut out entirely leads to cracking of tube sheets, leakage and distortion.

The fighting ships of the world's navies have almost to a unit adopted oil fuel with splendid results, and there is no doubt, before the naval authorities of the various countries cut away from coal and adopted oil as a fuel, they were abundantly satisfied of a continuous supply of suitable fuel distributed practically all over the world.

How extremely important it is that the supply of oil fuel for naval ships should be beyond any possibility of interruption by enemy ships has at various times of recent date caused grave concern, and very drastic measures have been provided for, should the necessity arise.

Forced draft, which is so closely identified with the name of the late James Howden, has played an important part in the development of marine boiler design. While it is true Mr. Howden introduced his forced draft prior to the period embraced in this paper, it is admittedly true that the system of forced draft has reached its fullest usefulness within the time under consideration.

The increased efficiency per square foot of heating and grate surface due to the use of a well-designed forced-draft system has meant smaller boilers for the power developed. The early users of forced draft had costly delays and troubles to adjust, as the many serious defects developed in boilers were usually blamed upon and largely due to the improper use of forced draft.

A greater experience, however, has shown the immense possibilities which lie in the use of heated air under pressure in accelerating combustion. It is unnecessary to go into details on the various systems now in use. The "closed stokehold" system has been confined almost entirely to naval or special ships and has achieved splendid results, although this method is much more expensive to install. In the modern freight steamer we have the usual fan delivering the air through the air ducts to the heater tubes and down the draft casings into the ashpits at a pressure usually not exceeding one inch in the ashpit. This system works uncommonly well, and good efficiencies are obtained if the air ducts and casings are well designed and do not slow up or pocket the air currents. A well-designed forced-draft system of good workmanship is much to be desired as air losses are all too common on many of the miserable, ill-fitting systems turned out.

In many cases it is evident that forced-draft installation has never received the necessary care and thought either in the layout or the dimensions; it has in so many

instances been treated as just so much of a boiler casing with the result that we have tortuous air ducts, poor distribution and crude mechanical attachments.

Well-designed and well-built forced-draft systems in capable hands have given excellent results both in upkeep and efficiency, but when careless or reckless use of forced draft has been permitted very serious trouble has arisen, as buckling of tube sheets, burning stay ends and nuts off, with the consequent leakage, have resulted.

The water-tube boiler by the nature of its construction will of course stand greater forcing with excessive draft pressures than the exposed flat plates in a shell boiler, but, no matter what the design or how good the workmanship of a boiler may be, it will not long withstand the reckless use of forced draft, and this can be accentuated to a marked degree when burning oil fuel. Many engineers proportion the fan output so that it is not possible to deliver air pressure in excess of normal.

During the period under review there have been few changes in marine-boiler design. The greatest progress has been in developing the splendid boiler-shop tools now in use, which have made boiler work of to-day of such high-class mechanical accuracy.

The water-tube boiler, also superheaters, have made only slow progress in the mercantile marine, largely, in the opinion of the writer, for the reason that the principal builders have been generally so fully occupied with government and land work that they have not found it necessary to press their product upon the attention of the shipowner or builder.

So far we have enumerated the various mechanical changes and development of types brought about by the increased powers and higher steam pressures, but let us consider the physical question these changes have presented to the engineer, and with which he must grapple with a greater or lesser ability.

The actual work of manipulating the main propelling power calls for an experience that can only be gained in the engine-room; nevertheless it calls for a highly trained and intelligent experience, but unquestionably the success, or otherwise, of any engineering installation depends almost entirely upon the efficiency and maintenance of the boilers, and the importance of a knowledge of values of feed water, feed heating, fuel, boiler circulation, draft pressures, time raising steam and time and method of taking steam off the boilers, are all considerations, the importance of which cannot be over-estimated, and the full efficiency and best results can only be gained where educated intelligence is combined with good, trained mechanical experience.

The efficiency of the propelling force as developed through the main and auxiliary engines, in the case of steam power, can never be greater than the power developed by the boilers, and as the power developed by the boilers depends almost wholly upon the experience and ability the engineer's staff may possess and bring to bear upon their work, it is at once evident to what a large degree the whole success of engineering research and mechanical production depends upon the trained knowledge of the seagoing marine engineer.

What may have been looked upon as comparatively safe when pressures of

160 pounds were in use is no longer so with pressures up to 220 pounds, as we have higher furnace and steam temperatures, also heavier shell plates, tube sheets and furnace plating.

Briefly, our seagoing engineer of to-day should possess a sound educated mechanical knowledge of the construction and principle of the costly machinery placed in his charge, and upon the fidelity and ability with which he discharges his duties so very much depends.

He should have a knowledge of fuel values in relation to coal or oil and a comprehensive grasp of what combustion actually means. He should know what corrosion means to metals and the preventable measures to adopt. He should understand the value of feed heating and the economies to be gained. He should understand what expansion of metals means and the risks that are run by turning live steam into cylinders or cold pipe lines not properly drained, or in raising steam in boilers in insufficient time. He should know what specific gravity, density of liquids, and flash point of oils are in relation to his daily tasks, and to qualify him for the important duties he has to discharge.

For the purpose of comparison and interest, I have taken the requirements of the Maritime Bureaus of the American, English, and German governments, pertaining to seagoing engineers, which are as follows:—

AMERICAN (Department of Commerce, Steamboat-Inspection Service).

Requirements of Board of Supervising Inspectors.

CLASSIFICATION OF ENGINEERS.

Chief.

34. Chief engineers of ocean steamers.

Any person holding chief engineer's license shall be permitted to act as first assistant on any steamer of double the tonnage of same class named in said chief's license.

Engineers of all classifications may be allowed to pursue their profession upon all waters of the United States in the class for which they are licensed.

First Assistant.

First assistant engineer of ocean steamers.

Engineers of lake, bay, and sound steamers who have actually performed the duties of engineer for a period of three years shall be entitled to examination for engineer of ocean steamers, applicant to be examined in the use of salt water, method employed in regulating the density of the water in boilers, the application of the hydrometer in determining the density of sea water, and the principle of constructing the instrument; and shall be granted such grade as the inspectors having jurisdiction on the Great Lakes and seaboard may find him competent to fill.

Any first assistant engineer of steamers of 1,500 gross tons and over, having had actual service in that position for one year, may, if the local inspectors in their

judgment deem it advisable, be licensed as chief engineer of lake, bay, sound, or river steamers of 750 gross tons or under, in which case license shall be issued on chief engineers' form of license, which shall be endorsed with authority to act as first assistant engineer of steamers of any tonnage for which he is qualified.

Any person holding a license as first assistant engineer, and having had experience as first assistant engineer for a portion of the year required for raise of grade, may substitute experience as second assistant engineer, while holding first assistant engineer's license, which experience as second assistant engineer shall only count as one-half; provided, that any person having had a first assistant engineer's license for two years, and having had two years' experience as second assistant engineer, shall be eligible for examination for chief engineer's license.

Second Assistant.

Second assistant engineer of ocean steamers.

Any person holding a license as second assistant engineer, and having had experience as second assistant engineer for a portion of the year required for raise of grade, may substitute experience as third assistant engineer, while holding second assistant engineer's license, which experience as third assistant engineer shall only count as one-half; provided, that any person having had a second assistant engineer's license for two years, and having had two years' experience as third assistant engineer, shall be eligible for examination for first assistant engineer's license.

Third Assistant.

Third assistant engineer of ocean steamers.

First, second, and third assistant engineers may act as such on any steamer of the grade of which they hold license, or as such assistant engineer on any steamer of a lower grade than those to which they hold a license.

Any person holding a license as third assistant engineer and having had twelve months' experience as junior engineer, or twelve months' combined service as third assistant engineer and junior engineer, or two years' experience as oiler or water tender, or two years' combined service as oiler and water tender, since receiving said license, shall be eligible for examination for license as second assistant engineer.

Inspectors may designate upon the certificate of any chief or assistant engineer the tonnage of the vessel on which he may act. (Sec. 4441, R. S.)

Qualifications Required for License as Engineer of Steam Vessels.

35. No person shall receive an original license as engineer or assistant engineer of steam vessels who has not served at least 36 months in the engineers' department of a steam vessel, a portion of which experience shall have been obtained within the three years next preceding the application; provided, that any person who has served three years as apprentice to the machinist trade in marine, stationary, or locomotive engine works, and any person who has served for a period of

not less than three years as a locomotive or stationary engineer, and any person graduated as a mechanical engineer from a duly recognized school of technology may be licensed to serve as an engineer of steam vessels after having had not less than one year's experience in the engine department of steam vessels, a portion of which experience shall have been obtained within the three years preceding his application, which fact shall be verified by the certificate in writing of the licensed engineer or master under whom the applicant has served, said certificate to be filed with the application of the candidate; and no person shall receive license as above except for special license, who is not able to determine the weight necessary to be placed on the lever of a safety valve (the diameter of valve, length of lever, distance from center of valve to fulcrum, weight of lever and weight of valve and stem being known) to withstand any given pressure of steam in a boiler, or who is not able to figure and determine the strain brought on the braces of a boiler with a given pressure of steam, the position and distance apart of braces being known, such knowledge to be determined by an examination in writing, and the report of examination filed with the application in the office of the local inspectors, and no engineer or assistant engineer now holding a license shall have the grade of the same raised without possessing the above qualifications. No original license shall be granted any engineer or assistant engineer who cannot read and write and does not understand the plain rules of arithmetic.

No person holding a special engineer's license (Form 878) shall be eligible for examination for a higher grade of license until such person has actually served two full seasons under the authority of his license and one additional full season in a subordinate capacity upon steamers requiring regularly licensed officers.

British (Requirements of British Board of Trade. Qualifications Required for the Various Grades of Marine Engineer).

Ordinary Certificates.

25. *Value of Ordinary Certificates.*—Ordinary Certificates will entitle the holders to go to sea in the grade certified as engineers of any vessel in the British Mercantile Marine.

26. *Second-Class Engineer.*—A candidate for a second-class engineer's certificate must not be less than 21 years of age.

(*a*) He must have served as an apprentice engineer for four years at least, and prove that during the period of his apprenticeship he has been employed in the manner set forth.

Journeyman's time will be considered as equivalent to apprenticeship.

Every applicant must produce testimonials of ability as an engineer workman to the satisfaction of the Board of Trade.

If the candidate has served as an apprentice engineer or as journeyman, under

the conditions above prescribed, for less than four years, he will be required to make up the deficiency or to complete this period of four years by service as engineer at sea on regular watch on the main engines or boilers of a foreign-going steamer.

If the candidate has not served at all as apprentice engineer or as journeyman, he will be required to have served at sea, in lieu thereof, as engineer on regular watch on the main engines or boilers, six years in a foreign-going steamer.

(*b*) In addition to the apprenticeship as above described, or the alternative sea service, the applicant must have served one year at sea as engineer on regular watch on the main engines or boilers of a foreign-going steamer, or eighteen months in a home trade steamer.

On and after January 1, 1915, the applicant will be required, in addition to the apprenticeship above described or the alternative sea service, to have served eighteen months at sea as engineer on regular watch on the main engines or boilers of a foreign-going steamer, or twenty-seven months in a home trade steamer.

(*c*) He must be able to give a satisfactory description of boilers, and the methods of staying them, together with the use and management of the different valves, cocks, pipes, and connections.

(*d*) He must understand how to correct defects from accident, decay, etc., and the means of repairing such defects.

(*e*) He must understand the use of the water gauge, pressure gauge, barometer, thermometer, and salinometer, and the principles on which they are constructed

(*f*) He must be able to state the causes, effects, and usual remedies for incrustation and corrosion.

(*g*) He must be able to explain the methods of testing and altering the setting of the slide valves, and method of testing the fairness of shafts and adjusting them.

(*h*) He must be able to calculate the suitable working pressure for a steam boiler of given dimensions and the stress per square inch on crank and tunnel shafts when the necessary data are furnished.

(*i*) He must understand the construction of steering engines, evaporators, feed filters, and feed heaters.

(*j*) He must understand the construction of centrifugal, bucket, and plunger pumps, and the principle on which they act.

(*k*) He must be able to state how a temporary or permanent repair could be effected in case of derangement of a part of the machinery, or total breakdown.

(*l*) He must write a legible hand, and have a good knowledge of arithmetic up to and including vulgar and decimal fractions and square root. He must also understand the application of these rules to questions about safety valves, coal consumption, consumption of stores, capacities of tanks, bunkers, etc.

(*m*) He must be able to pass a creditable examination as to the various constructions of paddle and screw engines in general use; as to the details of the different working parts, external and internal, and the use of each part.

(*n*) He must possess a creditable knowledge of the prominent facts relating to combustion, heat and steam.

27. *First-Class Engineer.*—A candidate for a first-class engineer's certificate must be not less than 22 years of age.

In addition to the qualifications required for a second-class engineer—

(*a*) He must:—

(1) Have served at sea for 12 months with a second-class certificate of competency or service, on regular watch on the main engines or boilers of a foreign-going steamer.

(2) Have served at sea for 18 months with a second-class certificate of competency or service, as first engineer of a home-trade steamer, or two years with a second-class certificate of competency or service as second engineer of a home-trade steamer.

(3) Have served 2½ years with a second-class certificate of competency or service as third engineer of a home-trade steamer, if, during the whole of that period, he has been the senior engineer in charge of the whole of a watch on the main engines and boilers; or

(4) Possess, or be entitled to, a first-class certificate of service.

On and after January 1, 1915, the candidate will be required, in addition to the qualifications required for a second-class engineer—

(1) To have served at sea for 18 months with a second-class certificate of competency or service, on regular watch on the main engines or boilers of a foreign-going steamship, as senior engineer in charge of the whole watch; or

(2) To have served at sea for 27 months with a second-class certificate of competency or service as first engineer of a home-trade steamer, or three years with a second-class certificate of competency or service as second engineer of a home-trade steamer.

(3) To have served 3 years 9 months with a second-class certificate of competency or service as third engineer of a home-trade steamer, if, during the entire period, he has been the senior engineer in charge of the whole of a watch on the main engines or boilers; or

(4) To possess, or be entitled to, a first-class certificate of service.

(*b*) He will be required to make an intelligible hand sketch, or a working drawing of some one or more of the principal parts of a steam-engine, and to mark in, without copy, all the necessary dimensions in figures, so that the sketch or drawing could be worked from.

(*c*) He must be able to take off and calculate indicator diagrams.

(*d*) He must be able to calculate safety-valve pressures and the strength of the boiler shell, stays and riveting.

(*e*) He must be able to state the general proportions borne by the principal parts of the machinery to each other, and to calculate the direct stress, the torsional stress, and the bending stress in round bars, and the direct stress and the bending stress in rectangular bars with given loads.

(*f*) He must be able to explain the method of testing and altering the setting of the slide valves, and to sketch about what difference any alteration in the slide valve will make in the indicator diagram and also the method of testing the fairness of shafts, and of adjusting them.

(*g*) He must be conversant with surface condensation, super-heating, and the working of steam expansively.

(*h*) His knowledge of arithmetic must include the mensuration of superficies and solids and the extraction of the square and cube roots, and the application of these rules to questions relating to the power duty, and economy of engines and boilers, and to the stresses in rods, shafts and levers of the engine. He should also be able to calculate the effect of the application of the lever, pulley, inclined plane, and other mechanical powers.

(*i*) He must understand the construction of, and be able to maintain in working condition, the auxiliary machinery which is placed under his charge, viz., refrigerating machinery, electric-light engines and dynamos, electric motors fitted to ships' boats, hydraulic machinery, and the various descriptions of steering engines, etc.

28. *First-Class Certificates Without Second.*—The Board of Trade may see fit to allow an applicant who, in consequence of service abroad, has had no opportunity to obtain a second-class certificate, to be examined for a first-class certificate although he does not possess a certificate of the lower grade, provided he is able to satisfy them as to the satisfactory character of his services, but these should be ample both as regards length and experience.

If any candidate, who has not got a second-class certificate of competency, fails to pass the examination for the first-class certificate, but passes that for the lower grade, he may be given a second-class certificate of competency, but no part of the fee will be returned. A candidate who has been permitted to be examined for a first-class certificate without first obtaining a second-class certificate of competency or a certificate of service, and who fails in his examination in practical knowledge, may not be re-examined for a certificate of the higher grade until he has served three months as watchkeeper with a second-class engineer's certificate of competency or service as required by the regulations. If the candidate fails in practical knowledge both for the lower as well as for the higher grade of certificate, he may be re-examined for a second-class certificate only, subject to the usual regulations relating to failure.

29. *Extra First-Class Engineer.*—This examination is voluntary, and is intended for such persons as wish to prove their superior qualifications and are desirous of having certificates for the highest grade granted by the Board of Trade.

30. *Extra Examinations, when held.*.—The extra examinations are held once in every three months, and at ports where examinations of engineers are ordinarily conducted. The examination extends over several days. According to present arrangements these examinations will begin on the second Tuesday in January, April, July, and October in each year.

31. *Notice Required.*—Notice must be given by the candidate at least one week before the day on which the examination begins, and these notices must be immediately reported by the examiners to the chief examiner in London.

32. *Qualification Required.*—A candidate for an extra first-class engineer's certificate must have served an apprenticeship of five years at least or, as an equivalent, three years' apprenticeship and three years at an approved technical school; or he must have served for one year at sea on regular watch on the main engines or boilers as senior engineer in charge of the whole of the watch while holding a first-class engineer's certificate.

(*a*) He must be able to write good English.

(*b*) He must possess a thorough knowledge of the construction and working of the different forms of marine engines and propellers in all their parts, and be so far acquainted with the fundamental principles of theoretical and applied mechanics as to comprehend the general principles on which the machine works, and to illustrate his knowledge of these principles by numerical examples.

(*c*) He must possess a knowledge of the theory of strain and stress sufficient to be able to deduct the ordinary rules for the bending of rectangular bars and for the twisting and bending of round bars.

(*d*) He must be acquainted with the principles of expansion and the modern theory of heat, and be able to solve, with the assistance of his own books or without books, according as the examination papers may be set, questions in economy and duty in connection with engines and boilers.

(*e*) He must understand how to apply the indicator and to draw the proper conclusions from the diagrams, and to construct the approximate diagrams for any given data.

(*f*) He must be able to produce, without a copy, a fair working drawing of any part of the machinery with figured dimensions fit to work from.

(*g*) He must understand the principles of the action of the screw propeller and the paddle-wheel, and must be able to estimate numerically the effect in speed of ship and consumption of fuel due to any alteration in pitch, diameter, revolutions, etc.

(*h*) He must be able to give a description of boilers and the methods of staying them, and must show that he possesses a knowledge of the theoretical principles which regulate their construction, and that he is able to calculate the strength of the boiler shell, stays and riveting.

(*i*) He must understand the general nature of the strains and stresses produced by the steam pressure, and by the expansions due to unequal temperatures in boiler shells.

(*k*) He must have a knowledge of safety-valve construction, and the principles involved in determining the size of a safety-valve, and the construction of spring-loaded and dead-weight valves.

(*l*) He must possess a thorough knowledge of the theory of combustion, the chemical composition of fuels, the evaporative duty of fuels of given composition;

the production of draught; the effect in regard to economy, safety, and wear and tear, of increasing or diminishing the proportion of heating surface of grate bar surface, of area of section of air passages, of area of water surface, of steam space capacity and water capacity.

(*m*) He must be able to explain the formation of scale and the precipitation of salt, and the precautionary means adopted in respect thereto, with jet condensers, and with surface condensers.

(*n*) He must understand the general principles involved in the construction of the barometer, thermometer, salinometer and steam and vacuum gauges.

(*o*) He must be familiar with the general results obtained from past experience in relation to corrosion, pitting and galvanic action in boilers, and the use of zinc and of soda in boilers.

(*p*) He must be able to give a variety of illustrations of how defects have arisen from accident, imperfect construction, or deterioration and how these defects may have been prevented, and the best way of repairing such defects.

(*q*) He must be familiar with the properties and processes of manufacturing and testing the ordinary materials used in the construction of machinery and must possess an intelligent knowledge of the properties of the lubricants, boiler cements, and india-rubber in general use in steamers.

(*r*) He must understand the causes of spontaneous combustion and the formation of explosive gases in coal holds, and the precautionary measures proper to prevent accidents from these causes.

(*s*) He must be acquainted with the principles and practice of the generation and application of electricity to various purposes on board ship.

(*t*) He must be able to explain the construction and working of the refrigerating machinery in use on board ship, the electric lighting plant, the steering engines, hydraulic and pneumatic engines, the pumps, and all other auxiliary machinery placed under the chief engineer's control.

(*u*) In order to deal intelligently with ballast tanks, the cocks, valves and pumps of which are under the chief engineer's control, and to cooperate the more readily with the master in keeping the vessel in a safe condition, especially when she is light, and when coaling operations are proceeding, candidates are expected to possess an elementary knowledge of the stability of floating bodies.

(*v*) He must possess a practical knowledge of ship construction, and understand the elementary principles involved, so as to be able to deal with engine and boiler seatings and to supervise and direct any repairs that may be required to an iron or steel ship.

If the candidate does not obtain 67 per cent of the total number of marks allotted for the papers he will be declared to have failed. The papers will be founded chiefly on the foregoing sub-paragraphs.

33. On and after January 1, 1915, a candidate for either a second-class or a first-class certificate, who within two years from the date of application to be examined has attended an approved course comprising general mathematical and

scientific instruction at a technical school recognized by the Board of Trade as suitable for the training of marine engineers, will be allowed to count time so spent as equivalent to sea service in the ratio of three months at the technical school to two months at sea. Time so spent cannot be accepted as equivalent to more than one-sixth of the total sea service required for either certificate, but a candidate who has been allowed to count such time on examination for a second-class certificate will not be debarred from counting similar subsequent time on examination for a first-class certificate.

Time spent in an approved marine technical school subsequent to obtaining a first-class certificate and within two years from the date of application to be examined, may also be accepted as forming part of the qualifying service required under paragraph 32, in the case of candidates for extra first-class certificates, but if such time is substituted for sea service, it will only count as equivalent thereto in the ratio of three months at the school to two months at sea.

In every case in which an allowance is made for time spent at a marine technical school, the candidate will be required to produce the principal's certificate for continuous and regular attendance at all the approved classes and for satisfactory progress.

Certificates for Engineers of Home-Trade Passenger Ships Propelled by Oil Engines.

34. *Oil-Engine Certificates.*—Candidates may be examined for second-class certificates of competency as engineer of vessels propelled by oil engines.

These certificates will entitle the holders to go to sea as second-class engineers of home-trade passenger ships propelled by oil engines, but will not entitle them to go to sea as second-class engineers of foreign-going ships or of home-trade passenger steamships.

35. *Second-Class Engineer (Oil Engines).*—A candidate for a second-class oil-engine certificate must be at least 21 years of age.

(*a*) He must prove:—

(1) Four years' experience at the making or repairing of machinery, of which at least six months must be at the making or repairing of oil engines, or

(2) Three and a half years' experience in charge of engines and boilers at sea or an equivalent suitable experience on shore.

And in addition to either (1) or (2):—

(3) Six months' experience with oil engines at sea.

NOTE:—Alternative service to the above may be considered, but it is essential that the candidate should have experience with oil engines, and have spent at least six months at sea in the engine-room of a seagoing vessel.

(*b*) He must write a legible hand, and have a good knowledge of arithmetic up to and including vulgar and decimal fractions and square root.

He must also understand the application of these and other rules to problems relating to spring and lever loaded relief valves, and be able to solve questions about

the relative speeds of a vessel at different revolutions, the capacity of oil tanks, etc.

(*c*) He must be able to give a clear explanation of the principle on which an oil engine works, and to show by means of illustrative sketches and otherwise that he understands the construction of those in general use.

(*d*) He must be able to describe the chief causes which may make the engine difficult to start, and to explain how he would proceed to remedy any defects.

(*e*) He must be able to show that he understands the mechanism of the starting and reversing arrangement, and is competent to deal with defects which may lead to failure in the prompt handling or reversing of the engine.

(*f*) He must have sufficient mechanical ability to be able to overhaul the engine, to adjust the working parts, and to put the engine together again in good working condition.

(*g*) He must be able to give satisfactory answers to the elementary questions numbered 305 to 310 inclusive in Appendix C.

(*h*) He must be able to prove (by actual trial if practicable) that he is competent to manipulate an oil engine when under way by starting, running the engine, stopping, reversing or slowing down.

(*i*) He must understand what is meant by the flash point and have a knowledge of the explosive properties of the oil generally used in engines when exposed in the open air and the danger of exposing any vapor from the oil to a light or of allowing any leak from the oil tanks, particularly into the vessel's bilges.

(*j*) He must understand the action of wire gauze diaphragms when placed in pipes and connections to oil tanks, etc., for the purpose of preventing the explosion or ignition of oil vapor therein.

(*k*) He must be able to take the necessary precautions to guard against the escape of inflammable vapor from the vaporizers when the engines are stopped.

(*l*) He must be able to explain the principle and construction of a dynamo and the construction and arrangement of primary and secondary batteries and induction coils, so far as is necessary for the efficient management of an oil engine.

36. *Workshop Service.*—Workshop service must have been performed in works where steam engines, boilers, etc., are made or repaired, but no time served before the age of fifteen will be counted.

Not less than two years of the apprentice time must have been spent at fitting, erecting, or repairing engines and machinery either in the works or outside. The remaining two years may be made up of time spent in engine works at fitting, erecting or repairing engines and machinery or at one of the other branches of the trade given below, or at an approved technical school (day) the time so spent to count as follows:—

Fitting, erecting, repairing or turning....Full time.

Working in drawing office.....Full time up to one year, and beyond one year one-half time.

Patternmaking.....One-half time with a maximum allowance of one year.

Planing, slotting, shaping and milling....One-third time.
Boiler-making or repairing.....One-half time.
Smith work.....One-half time with a maximum allowance of one year.
Coppersmith work.....One-third time with a maximum allowance of six months.

In the event of the apprentice time being extended to five years or more, four years at machining followed by one year at erecting may be accepted as qualifying.

37. *Workshop Service Other Than the Above.*—When the workshop service has been performed in a place where engines are made, but not in the manner specified in paragraph 36, the case must be referred to the Board of Trade with a report upon the service performed. If the service be such as is useful training for an engineer, the board may accept the service; but in every such case the applicant must prove additional engine-room or marine-engine workshop service as required in the succeeding paragraph.

38. *Workshop Service where Engines Are not Made.*—When the workshop service has been performed in a place where steam-engines are not made or repaired, and the class of work done is similar to that required in engine making, the service may be accepted with an additional year of qualifying service; that is, four years' workshop service and either two years at sea on regular watch, or one year at engine fitting in a suitable marine-engine workshop and one year at sea in the engine-room. The approval of the Board of Trade must be obtained in every such case before the candidate is examined.

39. *Technical Schools.*—Time spent after the age of fifteen at a technical day school (recognized by the Board of Trade) as suitable, where there is an engineering laboratory, may be taken into account and accepted as equivalent to artisan service, usually at the ratio of three years in the technical school to two in artisan service, provided the applicant has taken the full engineering course and can produce the principal's certificate for regular attendance at all the approved classes and for satisfactory progress; and provided also that the remaining portion of the time has been spent in works where steam engines, boilers, etc., are made or repaired, in accordance with the scale of values indicated above.

40. *Sea Service.*—The sea service required by these regulations is, unless otherwise stated, service performed in foreign-going ships of at least the nominal horse-power specified for the respective grades of certificates. The nominal horse-power, as given on the vessel's certificate of registry, may in all cases be accepted by the examiners.

41. *Qualifying Service Defined.*—In the case of candidates for first-class certificates qualifying service means, as a rule, service on regular watch on the main engines or boilers as senior engineer in charge of the whole watch. When, however, three or four engineers are on watch at the same time the service of the two seniors may be allowed to count, and when not less than six engineers are on watch

together that of the three seniors, provided the certificate from the superintending engineer is produced stating the number of engineers on watch, the rank held by the applicant and that he was in full charge of a watch on a definite section of the main engines or boilers. During the whole of the period claimed, candidates must have been in possession of second-class certificates.

In the case of candidates for second-class certificates qualifying service means service as engineer on regular watch on the main engines or boilers.

In no case will time spent in clerical work be allowed to count.

42. *Further as to Qualifying Service.*—Only such service as gives the experience required to make a man thoroughly competent as a seagoing engineer is accepted as qualifying service. Even for a second-class certificate the candidate must prove to the satisfaction of the examiner that he is qualified by experience and knowledge to act as chief engineer in an under-powered steamer of 99 nominal horse-power on a voyage, say from England to Egypt, taking full responsibility for engines and boilers.

German (Marine Engineering Bureau Requirements).

For admission to the examination for engineers of the second class it is required as follows:—

During apprenticeship, must attend evening classes to study the theory of engineering and learn English.

After the fifteenth year of age:—Either (*a*) One must serve 72 months in steam-engine or motor-construction works, in steam-engine or motor-repair works and on the engineering staff of ocean steamers; at least 36 months must be spent in steam-engine or motor works, and at least 24 months on the engineering staffs in voyages of suitable steamers as assistant engineers; or

(*b*) After passing the examination for third-class engineer one must spend at least 24 months as engineer, and either before or after the examination for third-class engineers, must have spent at least 36 months as machinist and blacksmith in steam-engine or motor works.

For admission to examinations for first-class engineer one must serve for at least 24 months after passing the examination for second-class engineer, in voyages of suitable steamers as engineer in short, medium or great voyages.

For admission to the preliminary examination for marine engineer (chief engineer) it is required:—

After passing the fifteenth year, one must have spent at least 66 months in machinery construction work in one of the larger construction firms for marine engines, and at least 36 months in the engineering staff of steamers. At least 36 months must be spent in one of the larger steam-engine works, of which six months must be spent in the blacksmith and brazier shops. At least 30 months must be spent on the engineering staff of suitable ocean steamers as assistant or in a higher position in short, medium or long voyages.

The time spent in short voyages is limited to 12 months.

Besides, a 12-months course at a technical marine engineering school recognized by the state is required.

For final examination for chief engineer, it is required:—

After passing the examination for engineer of the first class, or after passing the preliminary examination for chief, one must spend 24 months in voyages of suitable steamers as engineer in medium and long voyages.

Besides, a 12-months course of the upper class of a marine engineering school recognized by the state is required.

The approval of the technical schools is in the hands of the Central State Board in conjunction with the Imperial Chancellor.

For candidates for second-class engineer, only that time is counted which is spent in steam-engine construction or repair works in its occupation of smith, brazier, machine builder and fitter. The time of service in the forging and brazing shops is limited to six months.

If one has passed the preliminary examination for chief engineer, he receives the certificate of engineer of the second class, and after ocean service of 24 months as engineer in short, medium or long voyages, without further examination he receives the certificate of engineer of the first class.

Authority for the bestowal of the certificate of machinist of the first class belongs to a qualified state board for the examination of qualifications; which considers, in addition to the qualifications shown by passing the preliminary examination for marine engineer, the proficiency as a second-class engineer, as well as the time served at sea.

NOTE:—The writer regrets that for obvious reasons it has been quite impossible to get reliable detailed particulars of the German engineering examinations.

It is not intended that we should produce an engineering theorist, but it is claimed that facilities should be provided for men, offering both educational and mechanical training of such a nature as to properly equip them for the duties of a marine engineer.

To properly equip men to become lawyers or doctors, splendid schools and institutions are provided in every large city which insist upon years of the highest educational training, and it is right that it should be so, otherwise a continuous supply of men of the proper caliber could not be assured.

Although education in general in this country is easy to obtain and is of the finest kind, yet extremely little is required of the engineer when he submits himself for examination as a test of his qualifications for the position he aspires to hold. The examinations and tests he has to pass are elementary and perfunctory to the last degree, entirely out of date in their requirements and out of touch with modern engineering. The tests and examinations should more adequately represent the educational and engineering necessities of the present day. Facilities should be provided by the Federal Government in those cities that are important

shipping centers, so that the proper training be placed within the reach of those who desire to study marine engineering. It would then be proper to require that the government examinations should be uniform and to the point aimed at, and further, should be of such a standard and of such a searching nature that only men of at least a fair education and good mechanical training could hope to pass the examinations.

This would not entail any hardship if certain specified educational institutions included in their day and evening classes (with a view to training marine engineers) such subjects as mechanical drawing, algebra, physics, taking up heat values, combustion, refrigeration, strength of materials, electric light, powers, etc., all with direct relation to and including an exhaustive study of the various types of marine engines, boilers, etc.

Facilities should be provided at a nominal rate to make it possible for this technical training to be acquired during the apprenticeship period, and thereby produce a better informed mechanic, and also for the seagoing engineer when he comes ashore to prepare and qualify himself for further examinations.

It should be required that men desiring to follow the profession of seagoing engineers meet the following requirements before going up for examination:—

1. The candidate for examination should be a citizen of the United States.

2. He should be not less than 21 years of age.

3. He should be able to read and write English fluently and be educated equal to the senior classes in the public schools.

4. He should have served not less than 3½ years learning to be a machinist or as a machinist, inclusive (if possible) of one year in the drawing office, with a firm building marine engines and boilers; or

He should have served not less than four years learning to be a machinist or as a machinist with a firm engaged in repairing marine engines and boilers; or

He should have served not less than three years learning to be a machinist or as a machinist with a firm engaged in general engineering work with 1½ years additional in a shop engaged in marine engineering.

This would go a long way to ensure a man whose hands had been trained and who had learned the functions of the essential parts of the marine engine.

The complex and exacting duties of the engineer on watch amply demonstrate that we can no longer afford to recruit our engineers from the men who come up through the stokehold. Such a condition is neither desirable nor fair to the men, the shipowner, nor the costly property placed in charge of the engineer.

To-day American engineers are paid the highest wages, and the shipowner has a right to expect in return that an engineer holding a government certificate should be a highly capable and efficient officer worthy of the responsibilities of his position.

It would be well for the engineering industry to establish, on a reasonable basis, conditions both as to actual training and remuneration during a period of apprenticeship that would attract good types of young men. It is unfortunately all too true that apprenticeship in the past has largely meant only a period of work,

with very meager remuneration and little or no attempt made to train him, with the result that he became a good or bad mechanic according to his natural ability.

Lately conditions have somewhat improved, but much more can be done; the apprentice ought to get actual instruction in his work, and encouragement to study should be given so as to develop his taste for the work. The employer will quickly get a return for this effort, as he will get the product of a man who has been taught to use his head. Had this line been more widely followed in the past there would not be such an absolute dearth of skilled mechanics to-day.

It is respectfully submitted that this Society and other kindred societies should, by discussion, representation and every other means within their power, impress upon the Government the extreme importance that the examinations, tests, qualifications and training of the seagoing engineer of the mercantile marine should be brought up to date and placed on a plane with that of other professions, whose responsibilities may be different in kind but do not exceed in degree that of the men in whose hands are placed the care and management of the machinery of our merchant ships so vital to the country's welfare at the present time.

DISCUSSION.

The President:—This is a very interesting paper, gentlemen, and I trust it will receive your serious attention. There are certain demands and requirements for engineers and engine-room and fire-room help that should be changed in order to bring about in the future a proper result. I trust that some of you who are intimately connected at the present time with the management of steamship companies and engineering departments will make comments on this paper. Mr. Haig, as I see, has compared the American method with the British and German methods of licensing engineers. If there is anything in our requirements that precludes our own men coming to the front, that requirement should be changed to suit our conditions. We will be glad to hear from any gentleman in the room.

Professor Herbert C. Sadler, *Member of Council:*—Mr. President and gentlemen of the Society, I think this paper is one which should have some discussion from our shipowning friends. Kipling has aptly described the inside of a modern warship as the heart of an eight-day clock, and I think that applies equally well to the modern merchant vessel. It always seemed to me rather strange that our requirements regarding seagoing engineers should be so low.

They have a term in England that distinguishes the man who runs the engine from a real engineer. Those of you who have been in England know that they call the man who drives the locomotive that pulls a train the engine-driver, and I think that would apply more nearly to some of our seagoing engineers than the term engineer. Many of them are not engineers. They are capable of driving engines, but possibly could not make the most simple repairs upon an engine, they are not skilled mechanics in any way, and I am afraid that in some cases their knowledge of engineering is somewhat meager.

The author of the paper touches on that point on page 35, where he says, "The examinations and tests he has to pass are elementary and perfunctory to the last degree, entirely out of date in their requirements and out of touch with modern engineering."

If we are to have an adequate mercantile marine, it seems to me that the question of the education of our engineers—not engine-drivers—who are to run our vessels is a very important one, and I should certainly like to hear some of the comments from our shipowning friends. I hope that discussion of this paper will be invited by correspondence, if some of the shipowners are not here now.

Mr. A. George Mattsson, *Member*:—I will just read two clauses from the paper, given on pages 21 and 22.

"In many cases it is evident that forced-draft installation has never received the necessary care and thought either in the layout or the dimensions; it has in so many instances been treated as just so much of a boiler casing with the result that we have tortuous air ducts, poor distribution and crude mechanical attachments.

"Well-designed and well-built forced-draft systems in capable hands have given excellent results both in upkeep and efficiency, but when careless or reckless use of forced draft has been permitted very serious trouble has arisen, as buckling of tube sheets, burning stay ends and nuts off, with the consequent leakage, have resulted."

I have taken pains to look into this matter for this reason—several ships for ocean service have been contracted for on the Great Lakes, at the yards in that vicinity, with boilers equipped with natural draft,—possibly some twenty-four ships or more; possibly forty-eight—whereas previously our Great Lake ships have always been equipped with forced draft. The reason given is this: regardless of the design—that may be first-class—the upkeep at sea is a most important element, that is to say, in connection with Mr. Sadler's discussion, if a machine is not properly taken care of it will not prove really satisfactory. We do know that forced draft is at least 20 per cent more economical than natural draft, and it is rather disappointing that after twenty years' work with forced draft we should go back to natural draft. All the more so that in employing natural draft the boilers for a given power will be considerably larger and heavier, thus decreasing the carrying capacity of the ship.

Furthermore, with the great scarcity of fuel and corresponding high price at the present time, every step should be taken to reduce the fuel demand and fuel bills, which of course is not accomplished with natural draft.

Mr. John H. Macalpine, *Member* (Communicated):—In Mr. Haig's excellent paper, on page 18, he speaks of the adoption of high-class alloy steel to avoid the failures which have occurred in gears and to improve their lasting qualities. The fact that these alloys are adopted is an admission that much trouble occurs from errors of alignment of the gear and pinion, producing highly localized tooth pressures or point contacts.

The adoption of high-class alloy does not remove the cause of failure. It may increase it, since difficulty of accurate machining is increased. If the material of the pinion only is changed, the danger of abrading the softer gear rims is increased. If both pinion and gear rims are made of high-class alloy, first cost is seriously raised, the harder material will intensify the localization of pressure, and great danger of abrasion will remain.

By mounting the pinions in a floating frame, the cause is removed and a very uniform

pressure assured along the whole length of the teeth. High-class alloys are then not necessary, though pinions so mounted safely carry over twice the safe load of a rigid gear of the same dimensions in which imperfect contacts are practically sure, sooner or later, to occur. These gear rims and pinions are forged of a good quality of mild carbon steel, and every floating frame gear which has been put in service is in perfect running condition to-day with the following exceptions:—

(*a*) The experimental gear tested in 1909 has been broken up, being found unsalable, as the reduction was only five to one.

(*b*) The S. S. Malmanque was torpedoed, but the gears worked admirably till she sank.

The action of the first gears of the U. S. collier Neptune was excellent. They were removed because, when it was determined to fit new turbines, the ratio of reduction was changed. When a suitable application is found they will again be put in operation.

Mr. Robert Haig (Communicated):—I feel grateful to the members who have taken part in this paper, as the chief value undoubtedly lies in discussion.

There is reason in our demand that our engineers should be well educated and well trained. Engineers who have been capably trained form one of the great assets of the nation to-day, as ships must be maintained and kept running if we are to worthily uphold our position in the transportation world.

The demand is for ships and more ships, and this demand will keep on increasing day by day and, while we may bend all our energies to the production of ships, it will avail us little unless we also concentrate our efforts in providing the means to supply that trained intelligence so absolutely necessary to our engineering personnel.

The President:—The thanks of the Society will be given to the author for the very complete discussion of the subject embraced in this paper.

We will now proceed to the next paper, No. 4, entitled "Wind and Fouling Resistance on the Neptune," by Mr. W. W. Smith, Member. This paper will also be read by the Acting Secretary.

The Acting Secretary read the paper.

THE EFFECT OF WIND AND FOULING RESISTANCES ON THE U. S. S. NEPTUNE.

By William W. Smith, Esq., Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

The object of this paper is to place before the Society data collected in connection with wind and fouling resistances on the U. S. S. Neptune. This vessel experienced considerable difficulty from these causes during her trials, two of which proved unsuccessful due to them. At the time, the considerable effect of wind and fouling was not appreciated until the data herein were prepared.

The large power due to the wind resistance of the Neptune results principally from the action of the wind on her considerable superstructure, and to a lesser extent to the rudder required to keep the ship on her course.

The superstructure of the Neptune is composed largely of the coal handling towers and gear. These structures are for the most part of lattice-work construction similar to that used in bridges. Professor Kernot in his experiments on the wind resistances of surfaces found that the lattice-work construction of a bridge, in which the area of the openings was 55 per cent of the whole area, experienced a pressure of 80 per cent of that upon a flat plate of the same area. The pressures upon cylinders and cones proved to be half of that upon their normal sections. These and other similar experiments confirm the fact that the large lattice-work superstructure of this vessel offers a great deal more resistance than the curved surfaces of other types. Considering that the wind resistance of the lattice-work structure of this vessel is 80 per cent of that of the solid area, it is evident that the effective area presented is as large as the sails of a fairly large vessel, and in a head wind, due to the very much higher relative wind velocity, the resistance offered is much greater than the wind power of the sails in driving a large vessel. (Note:—The wind power at a given speed varies as the square of the relative velocity.)

With a relative wind velocity of 45 knots (absolute wind velocity = 31 knots, speed = 14 knots), the wind resistance of the Neptune as shown later is about 50,700 pounds ($R = 25 V_r^2$). Since the unit wind pressure (pounds per square foot) on a flat plate normal to flow is 8.7 pounds ($P = \frac{4.3}{10^3} V_r^2$), the theoretical effective area is 4,900 square feet.

The large effect of wind resistance on the Neptune, as noted herein, is substantiated by the experiences of the captains of four other vessels of her class. In the case of the Jupiter, the commanding officer stated that a strong head wind

made it necessary to increase the revolutions by 10 revolutions per minute when steaming in formation with other vessels at about 12 knots speed. The captain of the Orion, who has had six years' experience in vessels of this class, stated that a strong head wind would reduce the speed over a knot at the same revolutions per minute and at a speed of 12 to 13 knots.

STANDARDIZATION TRIALS OF FEBRUARY 10 AND 11, 1912

After installing the second set of propellers, the Neptune proceeded to Rockland, Maine, to standardize over the measured mile course. The trial of February 10 was run in a high wind, and the power required for the full speed was so much in excess of the designed power (about 1,350 shaft horse-power) that it was concluded that the wind resistance of the unusually large superstructure was the principal cause of it, although but little data were available upon which to base this conclusion. It was therefore decided to repeat the trial under favorable conditions. The trial of February 11 was run in a very light wind, the power required for the full speed being 1,050 shaft horse-power less than that found the day before. This demonstrated the unusually great wind resistance of the Neptune and vessels of her type, which is much larger than that of most vessels, and much larger than generally supposed. The results of these trials are given in Tables I and II and in Fig. 5, Plate 5.

Although the ship had been out of dock eighty-seven days, the resistance due to fouling was small, due probably to the fact that she had been in comparatively fresh water before starting for the trial.

STANDARDIZATION TRIALS OF SEPTEMBER 29 AND NOVEMBER 17, 1915.

On September 29, the Neptune ran official standardization trials under the direction of the Naval Board of Inspection and Survey at Rockland, Maine, under practically the same wind conditions that existed during the trial of February 10, 1912, and although the machinery developed a large excess over the designed power, the speed was half a knot below that required for the full speed of 14 knots. It was apparent that the resistance was abnormally great, as shown by comparison with the designed conditions, Tables III, IV and V, which show that the power required for the full speed under these conditions would have been 41 per cent greater than the designed power. Table VI shows the large difference between the full power of the Neptune and other vessels of her class.

The large variation in speed, revolutions per minute and power during standardization runs for the Neptune, as compared with the U. S. battleship New York and the U. S. destroyer McDougal, are shown in Tables IX to XIV. These tables, together with Table XV, show the relatively much greater effect of wind on a vessel of the Neptune type than on vessels of usual design.

Inspection after the trial showed that the bottom was somewhat foul. In view of the high wind during the trial and the foul condition of the bottom, it was decided to clean and paint the bottom and run a second trial.

The estimated horse-power due to wind and frictional resistances during this trial are shown in Table VII. The total estimated power agrees very closely with the power obtained from the official standardization power curve by extending it to 14 knots speed. Since the wind conditions were practically the same as during the trial of February 10, 1912, the difference in power determined from the trials of February 10 and 11, 1912, was assumed to apply in this case also. The increase in frictional resistance due to fouling was taken from the curve of fouling resistance, Fig. 4 (point *D*), which was determined experimentally in the U. S. Model Basin,* it being assumed that the Neptune's bottom fouled at the same rate as the experimental plates which were submerged in approximately the same locality where the Neptune was anchored most of the time between August 19 and September 27 prior to the trial.†

After having her bottom cleaned and painted, the Neptune proceeded to Rockland, and ran the standardization trial of November 17, the data for which are given in Table VIII. The wind conditions during this trial were not very favorable, which accounts for the 550 shaft horse-power difference between the designed full power and the full power obtained on this trial.

EFFECT OF WIND RESISTANCE DURING VOYAGES.

The conditions being suitable, wind resistance observations were made during two voyages—from Boston, Mass., to Norfolk, Va. (Tables XVI to XVIII); and from Norfolk, Va., to Rockland, Maine (Tables XIX and XX). These tables, which show clearly the unusually great effect of wind resistance on the Neptune at cruising speeds of about 12 knots, may be summarized as follows:—

(*a*) At the same speed—

The revolutions per minute are increased from 11 to 18 per cent.

The power is increased from 53 to 89 per cent.

(*b*) At the same revolutions per minute—

The speed is reduced from 11 to 19 per cent.

The power is increased from 17 to 24 per cent.

Table XVI gives a continuous record of wind conditions progressing from a light wind abeam to a strong wind ahead, and the effects thereof.

It may be noted that the Westinghouse hydraulic dynamometer, which indicates continuously on a gauge the torque on the reduction gear wheels, is especially well suited for investigations of this nature because the measurement of power is quick and easy. It is a regular routine on the Neptune for the engineer on watch to record hourly in the engine-room log the dynamometer pressure and the revolutions per minute. The dynamometer pressure is indicated on an accurate test gauge which can be correctly read by any engineer. From this record, the power

*See paper entitled "Variation of Frictional Resistance of Ships with Condition of Wetted Surface," by Naval Constructor William McEntee, U. S. N., read before the Society, November 18, 1915.

†The Neptune was anchored in Hampton Roads, Va., and the plates were submerged in the waters of Chesapeake Bay near Norfolk, Va.

at any time can be obtained, which is most useful in checking the performance of the machinery and propellers. Such a means of measuring and recording power should be most useful in checking accurately the performance of merchant as well as naval vessels.

There was not much sea in either of the above cases, and, while it added to the resistance somewhat, its effect was probably small.

The values of the coefficient C from these voyages agree fairly well with the value obtained from the trial of February 10, 1912, in smooth water.

WIND RESISTANCE OF NEPTUNE AS DETERMINED FROM MODEL.

The wind resistance of the Neptune's model was measured in the wind tunnel of the Washington Navy Yard, as described by Naval Constructor William McEntee in his paper entitled "Notes from the Model Basin," which was read before the Society, November 16, 1916. Views of the model in the wind tunnel are shown in Plates 1 and 2. The resistance curve determined by experiment, and a similar curve computed with a constant value of C, are shown in Plate 3. The maximum difference between these curves is about 10 per cent at a velocity of 23 knots. Values from these curves, together with the horse-powers due to wind resistance at a speed of 14 knots, are given in Table XXI.

It will be noted that the values of C determined from the model experiment do not agree with those obtained from the observations made on the ship, as follows:—

C from model experiment	10.0 to 11.4
C from observations on ship	25.5 to 28.0

The reason for this difference is not known. The accuracy of the resistance as measured in the wind tunnel is beyond question, but the rigging of the model may have been less. On the other hand, the wind velocities on the ship were estimated closely, it is believed, but still their accuracy is open to question. However, the error of estimate could not be large enough to cover the large difference as noted above.

The object of this paper is not to fix with accuracy the value of C, but to show the large differences of power which were observed on the ship under regular service conditions with strong and light winds. While the exact values of the wind velocities are open to question, the powers, which were accurately measured, are considered reliable.

THE EFFECT OF WIND AND FOULING ON STANDARDIZATION TRIALS.

The object of standardizing the propellers of a vessel is to determine the relation between the speed, revolutions per minute, and power under standard conditions with respect to the resistance. It is therefore obvious that these standard conditions must not be departed from sufficiently to appreciably affect the resistance, for otherwise the results of the standardization will be rendered inaccurate.

The standard requirements in standardizing naval vessels are a given displacement and trim, a clean bottom, smooth and deep water. For these conditions the designed resistance is given by:—

$R_d = R_{fo} + R_{wo} + A$, where
R_d = the total designed resistance.
R_{fo} = the frictional resistance with a clean bottom.
R_{wo} = the wave resistance in smooth water.
A = a small allowance to cover unknown elements.

Under actual trial conditions, the resistance is given by:—

$R_t = R_d + R_f + R_w + R_p + R_t + R_n + R_s + R_r + R_h$, where
R_t = the total trial resistance.
R_f = the increase in the frictional resistance due to fouling.
R_w = the increase in the wave resistance due to rough water.
R_p = the increase in resistance due to displacement.
R_t = the increase in resistance due to trim.
R_n = the increase in resistance due to wind.
R_s = the increase in resistance due to bad steering.
R_r = the increase in resistance due to not maintaining the same revolutions per minute with both propellers.
R_h = the increase in the resistance due to shallow water.

The above errors should of course be reduced as far as possible, and the propellers of a vessel should be standardized under conditions approximating the ideal standard in order to obtain accurate and reliable results. Variations from the standard conditions due to slight fouling and moderate wind resistance have been frequently supposed to be negligible, but this is far from the fact, especially in certain types of vessels such as the Neptune, as shown herein, which emphasizes the importance of not deviating too far from these conditions.

In the case of vessels of high power with curved and inclined surfaces of moderate area exposed to the wind, the wind resistance is very much less in proportion to the total designed resistance. As an illustration, suppose we take as examples the North Dakota and the Neptune, both of which have about the same displacement. It is assumed that, for the same conditions, the total wind resistance of the North Dakota at a speed of 21 knots is the same as that of the Neptune at 14 knots. Table XV shows that the variation from the standard wind conditions makes a difference of power for the North Dakota of 3.6 per cent, which, for practical purposes, may be regarded as negligible. But for the Neptune the difference of power is 16.6 per cent, which makes the results too inaccurate for any usefulness whatever.

The adverse effects of unfavorable conditions during a standardization trial are, of course, extended to the full speed and other trials, since it is necessary

during these trials to maintain the increased revolutions as determined by standardization. For example, according to the standardization of September 29, the Neptune would have had to maintain 118 revolutions per minute during her full speed trial, which would have required 7,400 shaft horse-power without wind, whereas, under standard conditions, as designed,* the revolutions per minute and power would give a speed of 15 knots. The increase in revolutions per minute and power in per cent of the designed are 7.3 and 31, respectively.

It may be noted that the standard conditions for the sea trials are average service conditions, in which considerable variation is considered permissible. However, the limit of these variations has not been fixed, which would be desirable, and it would seem that 15 per cent variation in power would be a good figure. As noted herein, in certain cases this increase may exceed 75 per cent, which is out of the question. By selecting the proper course during trials, which is frequently done, the resistance and power for the required revolutions per minute can be maintained within a specified limit.

WIND VELOCITY AND RESISTANCE.†

If a flat plate is exposed to the impact of a large current of air as shown in Plate 6, the air impinging on the plate will be deflected and decelerated with respect to the direction of flow, causing a pressure on the plate in accordance with the formula:—

$P = M \cdot a$, where

P = the total pressure or force acting on the plate in the given direction.

M = the total mass acting on the plate.

a = the deceleration, or loss of velocity in the given direction.

Theoretically, the total mass acting on the plate depends on the projected area of the plate normal to flow, as shown in Plate 8, the velocity and the density as given by:—

$M = m \cdot A_p \cdot V = \frac{W}{g} \cdot A \cdot V \cdot \sin \alpha$, where

m = the unit mass = $\frac{W}{g}$

W = the specific weight, or the weight of 1 cubic foot in pounds.

g = the acceleration due to gravity = 32.2.

V = the velocity in feet per second.

A_p = the projected area in square feet = $A \cdot \sin \alpha$.

A = the actual area in square feet.

α = the angle of inclination of the plate to the direction of flow.

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*Since the trial of November 17 was also run under unfavorable conditions, the values obtained exceed those for standard conditions, and consequently are not used in this comparison.

†For complete information see "Speed and Power of Ships," D. W. Taylor, pp. 84–87; "Mechanical Engineers' Handbook," Lionel S. Marks. Section on Aeronautics by J. C. Hunsaker, pp. 1,246–1,261; "Resistance of the Air and Aviation," G. Eiffel. Translated by J. C. Hunsaker; "Aerodynamics" (2 vols.), F. W. Lanchester.

The acceleration or deceleration in any direction is given by the change of velocity in that direction, viz:—

Acceleration (–), $a = (-)\ V_2 - V_1$.

Deceleration (+), $a = (+)\ V_1 - V_2$, where V_1 and V_2 are the initial and final velocities in the given direction.

The acceleration and deceleration with respect to the axes of x and y, as shown in Plate 8 (3), are given by:—

$$a_x = (+)\ V - V_x = (+)\ V - V \cos \alpha = (+)\ V\,(1 - \cos \alpha)$$
$$a_y = (-)\ V_y - 0 = (-)\ V \sin \alpha$$

For normal impact as shown in Plate 8 (7 and 8), $\alpha = 90^\circ$, $a_x = (+)\ V - 0 = (+)\ V$, and $a_y = (-)\ V - 0 = (-)\ V$ to each side, the resulting forces being balanced.

With reference to any axes r and s, as shown in Plate 8 (4), the acceleration is given by:—

$$a_r = (+)\ V_{r_1} \pm V_{r_2} = (+)\ V \sin B \pm V \sin \phi = (+)\ V(\sin B \pm \sin \phi)$$
$$a_s = (-)\ V_{s_2} - V_{s_1} = (-)\ V \cos \phi - V \cos B = (-)\ V(\cos \phi - \cos B)$$

The acceleration is maximum in a direction half-way between the initial and final directions, as shown in Plate 8 (5), and is given by:—

$$a_{r_1} = (+)\ V_{r_1} - V_{r_2} = (+)\ 2\,V_r = (+)\ 2\,V.\ \sin \frac{\alpha}{2}$$
$$= (-)\ 2\,V \left(\frac{1 - \cos \alpha}{2}\right)^{\frac{1}{2}}$$
$$a_{s_1} = V_{s_2} - V_{s_1} = 0$$

With reference to axes normal and parallel to the plane, the acceleration is given by:—

$$a_n = (+)\ V_n - 0 = (+)\ V \sin \alpha$$
$$a_m = (-)\ V - V_m = (-)\ V - V \cos \alpha = (-)\ V(1 - \cos \alpha)$$

For a given initial velocity the acceleration depends on the angle through which the current of air is turned. Likewise, the pressure acting on the plate in any direction depends on the change of momentum, $M\,.\,V$, in that direction.

The pressure acting on the plate in the directions x and y are obtained from the mass acting on the plate and the change of velocity in these directions as follows:—

$$P_x = (+)\frac{W}{g}\,.\,A\,.\,V^2 \sin \alpha\,(1 - \cos \alpha)$$
$$P_y = (-)\frac{W}{g}\,.\,A\,.\,V^2 \sin^2 \alpha$$

The resultant pressure is obtained from P_x and P_y, or a_{r_1}, Plate 8 (5), and is given by:—

$$P = P_x^2 + P_y^2 = 2\frac{W}{g}A \,.\, V^2 \sin\alpha \left(\frac{1-\cos\alpha}{2}\right)^{\frac{1}{2}}$$

The pressure normal to the plate, which is less than the resultant pressure, is given by:—

$$P_n = \frac{W}{g}A \,.\, V^2 \sin^2\alpha$$

The above theoretical conditions, however, are deviated from actually due to the irregular flow of the air, as shown in Plate 6. All of the column of air in front of the plate is not acted upon so as to deflect it through the angle α, which the plate makes with the current, and also there is a suction produced behind the plate due to the viscosity of the air flowing past it. Under actual conditions, therefore, the pressure acting on the plate is given by:—

$P = K \,.\, A \,.\, V^2$, where

P = the total resultant pressure acting on the plate in pounds.

A = the area of the plate in square feet.

V = the velocity of the air relative to the plate in feet per second.

K = a coefficient depending on the inclination, shape, size and arrangement of the surface.

K will depend also on the density and velocity, but for ordinary purposes these effects can be neglected by assuming standard conditions. The values of K for flat plates of various sizes normal to the current of air and of square and circular shapes are as follows:—

Diameter of disc or side of square in feet	*K*
0.5	1.25×10^{-3}
1.0	1.33×10^{-3}
2.0	1.46×10^{-3}
3.0	1.48×10^{-3}
4.0	1.50×10^{-3}
5.0	1.52×10^{-3}
10.0	1.52×10^{-3}

Where the plate is inclined, K varies irregularly with the angle of inclination and aspect ratio* as shown in Plate 7, from which the ratio $\frac{K_i}{K_{90}}$ is obtained.

K_i = the coefficient for the given angle of incidence = $K_{90} \times$ ratio $\frac{K_i}{K_{90}}$

K_{90} = the coefficient for a flat plate normal to flow as given above.

*Aspect ratio is the ratio of the span of a rectangular plane or wing measured across the wind to the depth measured in the direction of the wind.

Where the shape of the surface is other than a plane, the coefficient K will have values which have been determined by experiment for the particular shape under consideration.

The normal pressure on the plate is theoretically given by:—

$P_n = P . \cos \frac{\alpha}{2}$, or practically we may write—

$P_n = K_n . A . V^2$, where

$K_n =$ a coefficient for the normal pressure similar to K for the resultant pressure. $\left(\text{Theoretically, } K_n = K . \cos \frac{\alpha}{2}.\right)$

When the surface upon which the air impinges is moving, the velocity of the air relative to the surface which causes pressure is given by the following formulae as applied to a vessel:—

(*a*) Where the ship is moving in the direction of the current, or wind—

(1) When the velocities are in opposite directions:

$$V_r = (+) S + V_a$$

(2) When the velocities are in the same direction:

$$V_r = (-) S - V_a$$

(3) When the absolute wind velocity is 0:

$$V_r = (+) S, \text{ where}$$

$V_r =$ the wind velocity relative to the ship in knots.
$V_a =$ the absolute wind velocity in knots.
$S =$ the speed of the vessel in knots.

When V_a is larger than S, V_r is in the same direction as S, and is marked (–), since it is herein assumed that velocities and resistances—

In the same direction as the course are (–).

In the opposite direction from the course are (+).

(*b*) Where the ship is moving in a different direction from the current of air, the velocity of the air relative to the ship is given by:—

$V_r = \pm (S^2 + V_a^2 - 2S . V_a . \cos B)^{\frac{1}{2}}$, the sign being marked in accordance with the direction, as noted above.

$B = 180^\circ - \alpha$,

$\alpha =$ the angle between the absolute wind direction and the course.

(*c*) The component of the relative wind velocity along the course is given by:—

(1) $V_c = \pm V_r . \cos \theta$, or

(2) For velocities in the opposite direction:

$$V_c = (+) S + V_b = (+) S + V_a . \cos \alpha$$

(3) For the same direction:

$V_c = (-)\ S - V_b = (-)\ S - V_a . \cos \alpha$, where

V_b = the component of the absolute velocity along the course.

V_c = the component of the relative wind velocity along the course.

Velocity diagrams showing the relative velocities for various conditions are given in Plate 9.

The wind resistance of a vessel is given by:—

$R = K . A_d . V_r^2$, where

R = the total wind resistance along the course in pounds.

A^d = the area exposed to the direct action of the wind.

K = a coefficient depending on the shape and arrangement of the surfaces, velocity, density, and direction of the air, etc.

Since the determination of A_d is difficult, and assuming standard atmospheric conditions, we may write:—

$R = C . V_r^2$, where

C = a coefficient depending on the area, shape and arrangement of the surfaces, and the direction of the wind.

For a particular vessel, C will vary with the direction of the relative wind and its velocity.

Plate 10, shows a theoretical vessel in which there is an extreme variation in the area exposed to the direct action of the wind with its direction relative to the ship, resulting in considerable variation in the coefficient C.

In such a case, where the wind impinges on flat bulkheads at an angle, the mass action on them theoretically varies with the projected area ($A_p = A_d . \cos \theta$) and the resistance along the course is theoretically given by:—

$R = K . A_d . V_r^2 . \cos^2 \theta$, or actually

$R = C . V_r^2$, as before, where

θ = the angle between the course and the relative direction of the wind.

The horse-powers due to wind resistance are given by:—

$$THP_w = \frac{R . S \times 101.33}{33{,}000} = \frac{R . S}{326}$$

$$SHP_w = \frac{THP_w}{PC} = \frac{R . S}{326 \times PC}, \text{ where}$$

THP_w = the thrust horse-power due to wind resistance.

SHP_w = the shaft horse-power due to wind resistance.

PC = the propulsive coefficient $= EHP \div SHP$.

For a given vessel, the values of C can be determined from observations on the vessel itself, from experiments on its model, or from the values of C for a similar

vessel. Where accuracy is desired, a curve of the values of C can be plotted on the relative direction of the wind as shown in Plate. 12.

C can be determined by observing the difference of power with a light and with a strong wind. The formulae which apply are:—

$$R_d = R_1 \pm R_2 = C_1 . V_{r_1}^2 \pm C_2 . V_{r_2}^2$$

$$SHP_d = \frac{R_d . S}{326 PC}, \text{ where}$$

R_d = the difference in the resistances, and

SHP_d = the difference in the shaft horse-powers due to wind resistances with light and strong winds.

R, V_r and C have the same significance as noted above. The sub-numbers 1 and 2 refer to the strong and light wind conditions respectively.

Where C is the same for both observations, it is given by:—

$$SHP_d = \frac{S . C}{326 PC} V_{r_1}^2 \pm V_{r_2}^2$$

$$C = \frac{SHP_d PC \times 326}{S (V_{r_1}^2 \pm V_{r_2}^2)}$$

There are three cases to which the above may be applied:—

(*a*) With light and strong winds, which are the conditions for most observations.

(*b*) With and without wind, which is the difference between the standard designed condition with 0 wind velocity and the actual conditions existing during trials or in service.

(*c*) Standardization trials under either of the above conditions. Single runs with and against the wind corrected for speed may also be used as noted under (*a*).

The formulae for the differences of resistance and power are:—

(*a*) $R_d = R_1 \pm R_2$, and $P_d = P_1 \pm P_2$,

(*b*) $R_d = R_1 - R_o$, and $P_d = P_1 - P_o$,

(*c*) $R_d = R_{m_1} - R_{m_2}$, and $P_d = P_{m_1} - P_{m_2}$, where

R_o is the resistance and P_o the power with 0 absolute wind velocity, which is the standard design condition upon which the power is based.

R_m is the mean resistance and P_m the mean power of standardization runs across the measured mile in opposite directions.

In the above, when there is no wind, or it is calm, the wind resistance is due entirely to the apparent wind caused by the motion of the vessel and is given by:—

$$R_o = C . S^2, \text{ where}$$
$$V_r = V_c = S.$$

Where the value of C is the same for standardization runs in opposite directions, the mean of the resistance is given by:—

$$R_m = \frac{R_1 \pm R_2}{2} = \frac{C}{2}\,(V_{r_1}^2 \pm V_{r_2}^2)$$

Also, the difference between the mean wind resistance for runs in opposite directions, and that for no wind, which is the standard condition, is given by:—

$$R_d = R_m - R_o = C\left(\frac{V_{r_1}^2 \pm V_{r_2}^2}{2} - V_{ro}^2\right)$$

And the difference of power between the actual and ideal conditions and the coefficient C are given by:—

$$SHP_d = \frac{R_d \,.\, S}{326PC} = \frac{S \,.\, C}{326PC}\left(\frac{V_{r_1}^2 \pm V_{r_2}^2}{2} - V_{ro}^2\right)$$

$$C = \frac{SHP_d \,.\, PC \,.\, 326}{S\left(\frac{V_{r_1}^2 \pm V_{r_2}^2}{2} - V_{ro}^2\right)}$$

The relative velocity along the course may also be used to determine the resistance as follows:—

$$R = C \,.\, V_r^2, \; = C\frac{V_c^2}{\cos^2\theta},$$

$$= D \,.\, V_c^2, \; = D\,(S \pm V_b)^2, \text{ where}$$

D is a coefficient similar to C and $= \dfrac{C}{\cos^2\theta}$

In the above formulae, V_c and D can be substituted in place of V_r and C. The following also apply:—

$$R_m = \frac{R_1 \pm R^2}{2} = \frac{C}{2}\,[\,(S + V_b)^2 \pm (S - V_b)^2\,]$$

$$= C\,(\,S^2 + V_b^2\,) \text{ where } R_2 \text{ is } +, \text{ and}$$

$$= C\,(\,2S\,V_b\,) \text{ where } R_2 \text{ is } -.$$

$$R_d = R_m - R_o,$$

$$= C \,.\, V_b^2, \text{ where } R_2 \text{ is } +, \text{ and}$$

$$= C\,(\,2SV_b - S^2\,) \text{ where } R_2 \text{ is } -.$$

It is possible to determine C, R and SHP_w during trials and in regular service when suitable conditions occur, but it is important that the propulsive conditions remain the same or are reduced to the same standard for both observations—with and without wind, or with a strong and light wind. It is also important to measure accurately:—(*a*) the wind velocities, (*b*) the speeds, (*c*) the powers.

Estimating the wind velocity by the eye, which is the usual method, is of course inaccurate. For accurate results the measurement should be made with an anemometer. These instruments are in universal use in the United States Weather Bureau Observation Stations for the measurement of wind velocities.

During standardization trials the speed is accurately determined, but at sea

this is more difficult and there may be considerable error. The speed can be obtained from the revolutions per minute corrected for existing conditions, or from a calibrated patent log.

A mistake which is frequently made in recording the direction of the wind in ships' logs is to observe the direction of the smoke or the colors, which gives the relative direction, whereas the absolute direction is required. The correct practice is to observe the direction of the waves caused by the wind, but this cannot always be done.

TABLE I.—*Comparison between Performances of Neptune in Light and Strong Winds at 14 Knots Speed, Showing Large Increase in Power Due to Wind Resistance. Standardization Trials of February 10 and 11, 1912.*

Trial	February 10	February 11	Difference
Wind	Strong*	Calm to light	....
Speed, knots	14	14	....
R. P. M.	135.0	130.8	4.2
S. H. P.	7,350	6,300	1,050

*Direction, on bow and quarter.

TABLE II.—*Standardization Trials of February 10 and 11, 1912. Wind Resistance Data.*

		February 10	February 11
1	*Speed, knots	14	14
2	R. P. M.	135.0	130.8
3	S. H. P.*	7,350	6,300
4	V_a, abs. wind velocity, knots	35	3
5	α_1, abs. wind direction, degrees,† N run	45	67.5
6	α_2, abs. wind direction, degrees, S run	135	112.5
7	V_{r_1}, relative wind velocity, knots, N run	45.9	15.4
8	V_{r_2}, relative wind velocity, knots, S run	—27	13.2
9	V_{c_1}, relative wind velocity,‡ knots, N run	38.8	15.2
10	V_{c_2}, relative wind velocity, knots, S run	—10.7	12.8
11	Θ_1, relative wind direction, degrees, N run	32	10
12	Θ_2, relative wind direction, degrees, S run	108	12
13	Coefficient C	28.0	....
14	Displacement, tons	19,463	19,457
15	Trim, by stern, inches	12¾	12½
16	Days out of dry dock	87	....

*From curve. †From ship's head. ‡Along the course.

TABLE III.—*Difference between Actual Performance on Standardization Trial of September 29, 1915, and Designed Performance.*

	Actual	Designed	Difference
Speed, knots	13.55	13.55	0
R. P. M.	113.88	106.5	7.38
S. H. P.	7,240	5,400	1,840
I. H. P. (S. H. P. + 0.92)	7,860	5,840	2,020
E. H. P. with appendages	.....	3,520	.....
Propulsive efficiency per cent $=\left(\frac{\text{E. H. P.}\times 100}{\text{S. H. P.}}\right)$	48.6	65.2	16.6

TABLE IV.—*Results of Trial of September 29, 1915, Compared with the Designed Conditions at the Designed Full Speed of 14 Knots.*

	Designed	Trial	Difference	Per cent difference
Speed, knots	14	14	....	....
R. P. M.	110	118	8	7.3
S. H. P.	5,900	8,300	2,400	40.6
Slip in per cent	8.85	15.0	6.15	....

Wind, 2 points on bow and quarter, force 6 to 7 (30 to 35 miles per hour). Bottom slightly foul.

TABLE V.—*Results of Trial of September 29, 1915, Compared with Designed Conditions at the Designed Full Speed R. P. M.*

	Designed	Trial	Difference	Per cent difference
R. P. M.	114	114	....	....
Speed, knots	14.52	13.55	0.97	6.7
S. H. P.	6,600	7,240	640	9.7
Slip in per cent	9.9	15.0	....	....

For conditions see Table IV.

TABLE VI.—*Power Required for a Speed of 14 Knots by the Neptune on Standardization Trial of September 29, 1915, Compared with Other Vessels of Same Class.*

	S. H. P.	I. H. P.*	Difference of I. H. P.
Neptune, Sept. 29, 1915 ‡	8,300	9,020	0
Neptune, Nov. 17, 1915 ‡	6,450	7,010	2,010
Neptune, Feb. 11, 1912 †	6,300	6,850	2,170
Jupiter	5,450	5,925	3,095
Proteus	.....	6,200	2,820
Nereus	.....	5,850	3,170

*I. H. P. = S. H. P. ÷ 0.92.
†Second set of propellers. R. P. M. for 14 knots (trial), 131.
‡Third set of propellers. R. P. M. for 14 knots (designed), 110.

TABLE VII.—*Estimated Horse-powers Due to Wind and Frictional Resistances for Standardization Trial of September 29, 1915.*

1	Speed, knots	14
2	Wind velocity, nautical miles per hour, estimated	35
3	Number of days out of dry dock *	40
4	S. H. P. at 14 knots as designed for standard trial conditions	5,900
5	S. H. P. due to increase in wind resistance as determined from trials of February 11 and 12, 1912, Table I	1,050
6	S. H. P. due to increase in frictional resistance due to fouling of bottom as determined from model basin curve, Fig. 4 †	1,320
7	S. H. P. as estimated above (4, 5 and 6)	8,270
8	S. H. P. from official standardization curve	8,300

* August 19 to September 29.

† Increase in resistance 30 per cent. Frictional horse-power of hull and appendages, 2,860. E.H.P. ÷ S. H. P. = 0.65. (Designed P. C. = 0.67, but it was less under the above conditions.)

TABLE VIII.—*Standardization Trials of September 29 and November 17, 1915, and Designed Conditions.*

1	Trial	Sept. 29	Nov. 17	Designed
2	Speed	14	14	14
3	R. P. M.	118	112.3	110
4	S. H. P.	8,300*	6,450	5,900
5	Absolute wind velocity, knots	35	25	....
6	Absolute wind direction, degrees, N runs	45	67.5	....
7	Absolute wind direction, degrees, S runs	135	112.5	....
8	Displacement	19,600	19,554	19,500
9	Trim, inches by stern	16½	16½	....
10	Days out of dock	40	8	....

*From extension of official standardization curve from 13.55 to 14 knots.

TABLE IX—*Standardization Data for U. S. S. Neptune on Trial of September 29, 1915, Showing Large Variation in Speed and R. P. M. for Same Power.*

Direction	S. H. P.	R. P. M.	Diff. in R. P. M.	Per cent diff.	Speed	Diff. in speed	Per cent diff.
N	5,307	100.06	4.62	4.3	10.87	2.63	19.5
S	5,307	104.68	....	....	13.50	....	....

TABLE X.—*Standardization Data for U. S. S. Neptune on Trial of September 29, 1915, Showing Large Variation of Power and Speed for same R. P. M.*

Direction	R. P. M.	S. H. P.	Diff. in power	Per cent diff.	Speed	Diff. in speed	Per cent diff.
N S	70.49 70.76	2,072 1,696	376	22.2	6.96 9.59	2.63	27.4
N S	94.48 94.79	4,520 3,919	601	15.3	10.26 12.10	1.84	15.2
N S	108.53 108.58	6,744 5,899	845	14.3	12.31 13.70	1.39	10.1

TABLE XI.—*Standardization Data for U. S. S. New York, Showing Small Variation in Power and Speed for Same R. P. M.**

R. P. M.	I. H. P.	Diff. in power	Per cent diff.	Speed	Diff. in speed	Per cent diff.
59.41 59.61	2,909 2,869	40	1.4	10.73 10.56	0.17	1.6
86.33 86.52	8,371 8,310	61	0.74	15.25 15.67	0.42	2.7
123.73 123.79	25,488 26,499	1,011	4.0	20.33 21.79	1.46	7.0

*From official trial report, Journal of American Society of Naval Engineers, 1915, p. 50.

TABLE XII.—*Standardization Data for U. S. S. McDougal, Showing Small Variation in Power and Speed for Same R. P. M.**

R. P. M.	S. H. P.	Diff. in power	Per cent diff.	Speed	Diff. in speed	Per cent diff.
133.87 133.99	176 184	18	1.0	7.61 8.68	1.02	11.5
324.59 324.95	2,702 2,715	7	0.26	19.70 19.26	0.44	2.3
607.11 606.60	16,237 16,451	224	1.35	30.29 30.96	0.67	2.2
634.28 634.09 634.66	17,806 17,681 17,779	125	0.7	31.00 32.07 30.91	1.16	3.8

*From official trial report, Journal of American Society of Naval Engineers, 1914, p. 867.

TABLE XIII.—*Comparison Showing Difference in Power for Standardization Runs in Opposite Directions at Same R. P. M. for Neptune, New York, and McDougal, Showing Relatively Large Difference in Case of Former.*

	High speed		Low speed	
	Diff. in power	Per cent diff.	Diff. in power	Per cent diff.
Neptune (S. H. P.)	845	14.3	376	22.2
New York (I. H. P.)	1,011	4.0	40	1.4
McDougal (S. H. P.)	125	0.7	18	1.0

TABLE XIV.—*Comparison Showing Difference in Speed for Standardization Runs in Opposite Directions at Same R. P. M. for Neptune, New York, and McDougal, Showing Relatively Large Difference in Case of Former.*

	Difference in knots	Difference in per cent of full speed
Neptune	2.63	18.8
New York	1.46	7.0
McDougal	1.16	4.0

TABLE XV.—*Comparison between Vessels of about the Same Displacement, but of Different Speeds and Construction, Showing Relatively Greater Effect on Vessel of Neptune Type.**

Vessel	Neptune	North Dakota
Displacement, tons	19,500	20,025
Speed (designed full), knots	14	21
S. H. P., for full speed under standard conditions	6,000	28,000
Increase in power due to strong wind	1,000	1,000
S. H. P., for full speed with strong wind	7,000	29,000
Per cent increase due to wind resistance	16.6	3.6

*It is assumed for illustration that the wind resistance of the North Dakota at 21 knots is the same as that of the Neptune at a speed of 14 knots. Actually, however, the resistance of the Neptune is greater under these conditions.

TABLE XVI.—*Effect of Wind Resistance on Speed and Power during Voyage from Boston, Mass., to Norfolk, Va., October 31 to November 2, 1915.*

Date	Watch	Wind		R.P.M.	Speed in knots by patent log*				Dynamometer pressure in pounds per square inch			
		Direction	Force, Beaufort's scale		Actual	With no wind	Diff. (*6*) and (*7*)	Per cent diff.	Actual	Designed	Diff. (*10*) and (*11*)	Per cent diff.
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Oct. 31	4th	Quarter	4	90	11.95	11.8	0.15	1.3	67½	68	½	0.8
Oct. 31	5th	Beam	2	90	11.86	11.8	....	....	67½	68	½	0.8
Oct. 31	6th	Beam	2¾	90	11.7	11.8	....	....	67½	68	½	0.8
Nov. 1	1st	Bow	3¼	90	10.93	11.8	.87	7.4	68.0	68	0	0
Nov. 1	2nd	Ahead	4½	90	10.8	11.8	1.0	8.5	72.4	68	4.4	6.6
Nov. 1	3rd	Ahead	6¼	90	10.3	11.8	1.5	12.7	79.0	68	11.0	16.2
Nov. 1	4th	Ahead	7	90	9.55	11.8	2.25	19.1	84.0	68	16.0	23.6
Nov. 1	5th	Ahead	7	90	9.67	11.8	2.13	18.1	83.6	68	15.6	23.0
Nov. 1	6th	Ahead	6¼	90	9.97	11.8	1.83	15.5	77.7	68	9.7	14.3
Nov. 2	1st	Ahead	4¾	90	10.6	11.8	1.20	10.2	76.9	68	8.9	13.1
Nov. 2	2nd	Ahead	4¾	90	10.05	11.8	1.75	14.4	76.7	68	8.7	12.8
Nov. 2	3rd	Ahead	5¾	90	11.15	11.8	0.65	5.5	76.2	68	8.2	12.0

*True speed = P. L. speed × 0.98.

TABLE XVII.—*Effect of Wind on Speed and Power at the Same R. P. M. during Voyage from Boston, Mass., to Norfolk, Va., October 31 to November 2, 1915.*

	Light wind abeam	Strong wind ahead	Diff.	Per cent diff.
R. P. M.	90	90	....	....
Speed, knots	11.55	9.35	2.25	19.1
Dynamometer pressure, pounds	68	84	16	23.6
S. H. P.	3,180	3,930	750	23.6
Slip in per cent	8.25	25.7	17.45	....
Wind, direction	Beam	Ahead	....	....
Velocity, knots	11	35	....	....

Note: See Table XVIII.

TABLE XVIII.—*Effect of Wind on R. P. M. and Power at Same Speed of Vessel during Voyage from Boston, Mass., to Norfolk, Va., October 31 to November 2, 1915.*

	Light wind abeam	Strong wind ahead	Diff.	Per cent diff.
Speed, knots	11.55	11.55	....	....
R. P. M.	90	106	16	18
S. H. P.	3,180	6,000	2,820	89
Slip, per cent	8.25	22.0	14.75	....

Note: See Table XVII. $V_r = 46.55$ and 15.3. $V_c = 46.55$ and 11.55. $C = 26.6$.

TABLE XIX.—*Effect of Wind on Speed and Power at Same R. P. M. during Voyage from Norfolk, Va., to Rockland, Me., November 12 and 13, 1915.*

	Light wind quarter and astern	Strong wind on bow	Diff.	Per cent diff.
R. P. M.	90	90	....	....
Speed, knots	11.70	10.45	1.25	10.7
Dynamometer pressure, pounds	63	74	11	17.4
S. H. P.	2,950	3,460	510	17.4
Slip in per cent	7.1	16.9	9.8	....
Wind, direction	Quarter and astern	Bow	....	....
Wind velocity, knots	13	24	....	....

TABLE XX.—*Effect of Wind on R. P. M. and Power at Same Speed of Vessel during Voyage from Norfolk, Va., to Rockland, Me., November 12 and 13, 1915.*

	Light wind quarter and astern	Strong wind on bow	Diff.	Per cent diff.
Speed, knots	11.70	11.70	....	....
R. P. M.	90	100	10	11.1
S. H. P.	2,950	4,500	1,550	52.5

Note: See Table XIX. $V_r = 33.3$ and 0. $V_c = 27.7$ and 0. $C = 25.5$.

TABLE XXI.—*Wind Resistances and Horse-powers for Various Velocities. Wind Ahead.* Velocities in Knots, and Resistances in Pounds.*

Absolute wind velocity	Relative wind velocity along the course		Wind resistance		C from 5 $C=\frac{R}{V_c^2}$	Thrust horse-power from 5 at 14 knots †	Shaft horse-power from 7 at 14 knots ‡
V_a	$V_c=V_a+S$	V_c^2	Computed $R=11\times V_c^2$	From model experiment			
1	2	3	4	5	6	7	8
0	14	196	2,158	2,095	10.7	90	139
10	24	576	6,330	5,750	10.0	247	381
20	34	1,156	12,750	12,250	10.6	526	811
30	44	1,936	21,350	21,750	11.2	935	1,440
40	54	2,916	32,100	33,500	11.5	1,438	2,220
50	64	4,096	45,100	47,500	11.6	2,040	3,140
60	74	5,476	60,300	63,600	11.6	2,730	4,200
70	84	7,056	77,500	83,000	11.78	3,560	5,490

* See curves, Fig. 3. † $T.\ H.\ P.=\frac{R.\ S.}{326}=R\times\frac{4.3}{102}$ for 14 knots speed.

‡ $S.\ H.\ P.=\frac{T.\ H.\ P.}{P.\ C.}=\frac{T.\ H.\ P.}{0.65}=T.\ H.\ P.\times 1.54.$

TABLE XXII.—*The Effect of a Head Wind on the Horse-powers Obtained on Standardization Runs. Velocities in Knots.*

Absolute wind velocity	Relative wind velocity				Shaft horse-power due to wind resistance*				
	Against wind $V_{c_1}=S+V_a$	With wind $V_{c_2}=S-V_a$	$V_{c_1}^2$	$V_{c_2}^2$	Against wind $P_1=C.V_{c_1}^2$	With wind $P_2=C.V_{c_2}^2$	Mean $P_m=\frac{P_1\pm P_2}{2}$	No wind $P_0=C.V_{r0}^2$	Difference $P_d=P_m-P_0$
1	2	3	4	5	6	7	8	9	10
0	14	14	196	196	323	323	323	323	0
10	24	4	576	16	950	26	488	323	165
20	34	— 6	1,156	36	1,910	— 60	925	323	602
30	44	—16	1,936	256	3,200	— 423	1,388	323	1,065
40	54	—26	2,916	676	4,820	—1,120	1,850	323	1,527
50	64	—36	4,096	1,296	6,750	—2,140	2,305	323	1,982
60	74	—46	5,476	2,116	9,040	—3,500	2,770	323	2,447

* $S.H.P._w=\frac{C.\ V_c^2\ S}{326PC}=1.65\ V_c^2\quad(C=25,\ S=14,\ PC=0.65)$

$S.H.P._d=\frac{C.\ S.}{326PC}\left(\frac{V_{c_1}^2\pm V_{c_2}^2}{2}-V_{c_0}^2\right)$

TABLE XXIII.—*Wind Velocities and Forces on Flat Surfaces Normal to Wind.*

Knots	Statute miles per hour	Feet per minute	Feet per second	Force in pounds per square foot
1	1.15	101	1.69	.0043
2	2.3	203	3.38	.0172
3	3.45	304	5.07	.0387
4	4.6	405	6.76	.0689
5	5.75	506	8.45	.1075
10	11.5	1,013	16.9	.43
15	17.25	1,520	25.35	.968
20	23	2,030	33.8	1.72
25	28.75	2,535	42.2	2.69
30	34.5	3,040	50.7	3.87
35	40.25	3,550	59.1	5.28
40	46	4,050	67.6	6.89
45	51.75	4,555	76.0	8.7
50	57.5	5,065	84.5	10.75
60	69	6,080	101.4	15.5
70	80.5	7,100	118.2	21.1
80	92	8,110	135.2	27.5
100	115	10,133	169.0	43.0

$F = K. V^2$, where

F = the force on flat surface normal to wind in pounds per square foot.

V = the velocity of the wind relative to the surface.

K = a coefficient with values as follows for a surface larger than 5 × 5 feet.*

1. For knots or nautical miles (6,080 feet) per hour.....4.3×10^{-3}
2. For statute miles (5,280 feet) per hour.....3.24×10^{-3}
3. For feet per minute.....4.2×10^{-7}
4. For feet per second.....1.51×10^{-3}

* K varies somewhat with the size and shape of the surface and with the density and velocity of the air. The above average values are suitable for practical use. For inclined and curved surfaces there is a great difference, and other values must be used.

TABLE XXIV.—*Beaufort's Scale of Wind Forces.*

Force	Statute miles per hour	Nautical miles per hour	Designation
0	0– 3	0 – 2.6	Calm
1	3– 8	2.6 – 6.95	Light airs
2	8–13	6.95–11.3	Light breeze or wind
3	13–18	11.3 –15.6	Gentle breeze or wind
4	18–23	15.6 –19.95	Moderate breeze or wind
5	23–28	19.95–24.3	Fresh breeze or wind
6	28–34	24.3 –29.5	Strong breeze or wind
7	34–40	29.5 –34.7	Moderate gale
8	40–48	34.7 –41.6	Fresh gale
9	48–56	41.6 –48.5	Strong gale
10	56–65	48.5 –56.4	Whole gale
11	65–75	56.4 –65	Storm
12	Over 75	Over 65	Hurricane

DISCUSSION.

THE PRESIDENT:—Is there any discussion of the paper just read, entitled "Wind and Fouling Resistance on the Neptune"?

NAVAL CONSTRUCTOR WILLIAM MCENTEE, U. S. N., *Member* (Communicated):—The data presented in this paper are of importance in calling attention, in the case of a ship like the Neptune, to the large variations in speed and power resulting from variations in the direction and force of the wind.

A point which is not brought out clearly in the paper is that the ordinary method followed in the Navy in standardizing ships over a measured mile is subject to a very considerable error when used under conditions where the wind has any very appreciable effect. The method of standardization consists in taking the revolutions per minute, the horse-power and the speed over a measured mile, and averaging the results when run in opposite directions to eliminate the tide effect. The results are first plotted as a curve of revolutions per minute on speed. It is clear, in the trial of a ship like the Neptune, that to attain a given speed a considerably greater number of revolutions per minute are required when running against the wind than would be required when running with the wind, or with no wind; so even if the tide is eliminated the average revolutions per minute speed curve so obtained really is not true for either of the two conditions—that is to say, it does not give the true revolutions per minute speed curve when against the wind, nor does it give it when running with

the wind. What is obtained is an average curve which is somewhat between the curves which would truly represent the two foregoing conditions. A similar criticism applies to the power curves so determined. The conclusions therefore reached in the paper, as in Table VII, result from the average conditions during the trials, and not the actual condition when running against the wind.

My interest in this matter has been increased by the conclusion reached by the author from his analysis of the trial and other data, that the wind resistance of the Neptune, when running at 14 knots against a head wind of 31 knots, is 50,700 pounds. This is 2.25 times as much as the resistance estimated from the wind tunnel tests of a carefully made and fully rigged model of the Neptune. This discrepancy has led me to attempt a further analysis of the trials.

Referring to Table VIII, it will be seen that on the trial of November 17, 1917, when the bottom was freshly painted, there was a wind of estimated velocity of 25 knots. On the south runs this wind bore 22½ degrees abaft the beam. The component in the direction of the ship's motion would be 8.3 knots per hour. This would not cause an increase in the resistance of a ship, but rather a small decrease which, however, may be neglected.

From the original trial data I have plotted for the south runs the shaft horse-power on revolutions per minute. This is a curve which is independent of speed measurements. For the sister ship, the Jupiter, there are available standardization data from trials run under ideal conditions, that is to say, in a place where there was ample depth of water, practically no tide and practically no wind. By plotting the shaft horse-power on revolutions per minute for the Jupiter, a curve is obtained for comparison with the Neptune's curve, as described above. There was a very slight difference in the pitch and diameter of the propellers on the two ships, but they were otherwise very similar. When a slight correction for these differences is made, it is found that the curves for the two ships agree identically, except that the shaft horse-power required to make 110 revolutions per minute on the Neptune, corresponding to 14 knots in smooth water and calm air, is about 2 per cent higher than the horse-power required on the Jupiter to make 108.7 revolutions per minute at the same speed.

The Jupiter's horse-power was measured by two independent methods—by the electrical input to the motors, and also by torsion meters on the shafts, these agreeing with each other. Further, a model of the ship propelled by its own propellers has been tested in the Model Basin, and the results at a speed corresponding to 14 knots check identically both as regard power and revolutions per minute. I conclude, therefore, that the shaft horse-power and revolutions per minute as determined for the Jupiter are correct, and that the power actually measured on the Neptune is 2 per cent high at 110 revolutions per minute and a speed of 14 knots. This may possibly be due to the dynamometer including in its measurements some of the reduction gear and bearing losses.

Having checked the power and revolutions per minute curve with the Jupiter and finding them to be in close agreement, I have plotted a revolutions per minute speed curve for the Neptune when running under ideal conditions. This curve would give the vessel a speed of 14 knots at 110 revolutions per minute. This, together with the power data obtained on the south runs on the trial of November 17, gives what appears to me to be a very reliable shaft horse-power and speed curve for that ship.

This revolutions per minute speed curve has been further checked by the following method:—On the south runs the difference between the observed speed and the true speed,

as determined from the above revolutions per minute speed curve, has been taken as the speed of the tide. By plotting this curve on time, it is possible to obtain the tide speeds for the intermediate north runs. Applying these tide corrections to the observed speeds on the north runs, the true speed through the water is obtained. From the test of a model of the propeller in the Model Basin, the propeller characteristics have been obtained, so that, for a given shaft horse-power and revolutions per minute, it is possible to compute the ship's true speed through the water. Applying this method to the observed shaft horse-power and revolutions per minute on the north runs, it is found that the speeds so obtained check with the speeds estimated from the tide correction curve.

A similar method has been applied to the trial data obtained on the trials of September 29, 1915. The results check with the estimated revolutions per minute speed curve as described above, and it is also possible to estimate fairly accurately the increased resistance due to the fouling of the bottom and to the wind on the north runs.

In Tables I and II below are given the results of an analysis of the high-speed runs on the trials of September 29, 1915. From these tables it will be seen that one important element in increasing the shaft horse-power when increased resistance is encountered has not been taken account of by the author in his paper. I refer to the decrease in the propulsive coefficient which results from the increased thrust on the propellers. But, even after taking this into consideration, it will be found that the estimated wind resistance, when running against the wind at a speed of 12.89 knots, is 24,000 pounds, compared with a resistance of 15,500 pounds estimated from the wind tunnel tests. The ratio between these two resistances is 1.55. In other words, the resistance on the trials is apparently 55 per cent greater than that which would be estimated from the wind tunnel tests.

A similar analysis, applied to the data given by the author in Table XVII, when the vessel was at sea on a voyage from Boston to Norfolk with a 35-knot head wind, shows that the wind resistance computed from the power, revolutions per minute and speed data, is about 60 per cent greater than would be estimated from the wind tunnel results. There does not appear to be any explanation for this discrepancy unless it be ascribed to more difficult steering, or to the fact that the wind causes an increase in the resistance due to the waves and sea.

With regard to the estimated resistance due to fouling on the trials of September 29, my figures show an increase in resistance of only about 11½ per cent as compared with 30 per cent estimated by the author. In this connection, also, there is some reason to doubt whether the fouling resistance is actually as much as 11½ per cent, for if the data given in Table XVII be correct, it appears that the vessel, with a light wind abeam, made 90 revolutions, 11.55 knots speed, with a shaft horse-power of 3,180. This checks exactly with the trial data obtained on November 17 after the vessel was docked and the bottom painted. In other words, it appears that, about a month after the trials of September 29, the vessel having been 70 days out of dock, the vessel in the open sea required only the same power to make the same revolutions and speed as was required on the trial course after the vessel had been cleaned and painted.

TRIALS OF SEPTEMBER 29, 1915.

TABLE I.—*Estimate of Fouling Resistance from South Runs Nos. 11 and 13.*

1. Average true speed, knots	14.25
2. Average revolutions per minute	115.75
3. Average shaft horse-power from dynamometers	7,207
4. Shaft horse-power, clean bottom, estimated from south runs, trial of November 17, 1917	6,350
5. Difference	857
6. Correction for change in P. C. $= 7{,}207 \times 1/65$	–110
7. Correction for dynamometers $857 \times .02$	–17
8. Increased shaft horse-power at 14.25 knots due to fouling	730
9. Per cent increase in resistance, due to fouling	11.5

TABLE II.—*Estimate of Wind Resistance from North Runs, Nos. 10 and 12.*

1. Average true speed, knots	12.89
2. Average revolutions per minute	112.23
3. Average shaft horse-power from dynamometers	7,222
4. Shaft horse-power (clean bottom) estimated from south runs, trial November 17, 1917	4,620
5. Difference due to fouling, wind, and decrease in P. C.	2,602
6. Dynamometer correction $2602 \times .02$	52
7. Shaft horse-power loss due to decreased P. C. $= \left(7222 \times \frac{.05}{.65}\right) \times .98$	544
8. Shaft horse-power loss due to fouling $730 \times \left(\frac{12.89}{14.25}\right)^3$	540
9. Shaft horse-power loss due to wind resistance	1,466
10. Total of 6, 7, 8 and 9	2,602
11. Wind resistance (lbs.) $= \frac{1466 \times .65 \times 33000}{101.3 \times 12.89}$	24,000
12. Estimated wind velocity (knots) from Table VII $= 12.89 \times .707 \times 35$	37.7
13. Wind resistance at 37.7 knots estimated from wind tunnel tests, Fig. 3 (lbs.)	15,500
14. Ratio of (11) to (13) $\frac{24000}{15500}$	1.55

MR. SMITH (Communicated):—Mr. McEntee points out that an average curve is obtained when a vessel is standardized in a strong wind. This is shown by the formulae on pages 51 and 52, and by the following:—

$$R_m = \frac{R_n + R_s}{2}, \text{ where}$$

$$R_n = C_n \cdot V_{rn}^2, \text{ and}$$

$$R_s = C_s \cdot V_{rs}^2$$

The sub-letters, *n* and *s*, refer to the north and south runs, and *m* to the mean. The other symbols have the same significance as given in the paper.

$$SHP_m = \frac{R_m . S}{326 . PC},$$
$$= (C_m . V_{rm}^2 + C_s . V_{rs}^2) . \frac{S}{326 . PC}$$

R_m and SHP_m vary according to the squares of V_r, and according to C, which depends on the direction of the wind as shown in Plate 12.

The effect of a head wind on north and south runs and on the mean power is shown in Table XXII. This, however, does not apply when the wind is not along the course, because of the variation in C as given in Fig. 12.

It was intended that Table VII should represent the effect of wind on the mean power results obtained by standardization in the usual way, and not the power running against the wind as noted. This likewise applies to all other tables of standardization data.

With reference to Table VIII, Mr. McEntee notes that the wind bore 22½ degrees abaft the beam. This is the direction of the wind, relative to the ship. The absolute direction was 45 degrees abaft the beam as given in the table. The effect of the wind pressure only would reduce the resistance, but the latter would be increased by the rudder required to keep the ship on its course. The total effect would undoubtedly be a reduction in the resistance. I do not agree with Mr. McEntee that this effect can be neglected, since the value obtained from the method given in the paper shows it to be otherwise as given in the following Table I. As pointed out in the paper, the value of C is not considered absolutely accurate, but the values are the nearest which could be determined from the actual performance of the ship and under the best conditions which were met with.

Mr. McEntee concludes that the Neptune's dynamometers were 2 per cent in error, basing his conclusions on the measurements on the Jupiter. From the Jupiter's trial data as published it appears that the measurements of power do not agree exactly as noted and as shown by the following:—

SHP as determined by torsion meter	7,152
SHP output of electric motors as determined by measurement of input and correcting for efficiency	7,050
Difference, *SHP*	102
Difference, per cent	1.45

Two per cent is a very small variation in the average power and is not considered to be beyond the limits of accuracy for such measurements. While the torsion meter and dynamometer may have instrumental accuracies within 1 per cent, which is not always the case, the average powers over the measured mile would probably not be accurate within 2 per cent, because of the errors in obtaining the average reading. To obtain a very high degree of accuracy, it would be necessary to use a recording instrument for obtaining the average reading. According to the author's observations, the power of vessels in traversing the measured mile is seldom within 2 per cent, and is frequently 5 per cent. This variation of course makes it difficult to obtain an average accuracy much less than 2 per cent to which the instrumental error must be added.

With reference to the bearing losses which might reduce the accuracy of the dynamometer, these losses are very small and not over about ¼ per cent. There are only two slow speed bearings on each gear, for which the revolutions per minute are 110 at full speed.

The pinion bearing losses, which are considerably more, do not affect the dynamometer which measures the total pressure on the gear teeth. The accuracy of the dynamometer of the Neptune is considered quite as good if not better than that of the electrical on the torsion meter determinations of the average power.

With respect to the propulsive efficiencies, the reduction in these valves due to the increased slip resulting from wind resistance should have been taken account of in computing the wind resistances. However, this does not apply to the increased power resulting from wind resistance, which is the total effect of the wind in increasing the power. The corrections for the propulsive efficiencies are not large, most of them being less than 2 per cent.

With reference to Table XVII, the speed as measured by patent log may have been in error, and it was not intended that these speeds should be regarded as very accurate. It is well known that speeds measured by patent log are not entirely accurate, and for this reason Mr. McEntee's conclusions in this connection are not concurred in. The "true speed" at the bottom of the table should read "estimated true speed." There is considerable possible variation in the condition of fouling in a vessel when the waters of the harbors are different with respect to freshness, etc. It may be noted that when the Neptune was placed in dry dock about November 10, 80 days after the previous docking, and about 43 days after the trial of September 29, that her bottom was unusually clean, and much more so than an inspection of the ship's side on September 29 indicated she was at that time. In fact, it appears that the fouling had decreased.

The author is unable to agree with Mr. McEntee's analysis as given in Tables I and II of his comments, since he has neglected the effect of the wind on the south runs—that is, the runs with the wind. This is the reason why a similar analysis was not included in preparing the paper. From observations of the performances of the Neptune in high winds, it is concluded that results approaching accuracy can only be obtained in making one set of observations in a calm or very light wind, and the other in a high wind. The reason for this is the effect of the wind on the steering when the wind is between the bow and the quarter and the absence of wind resistance data for these directions. Under these conditions, the rudder required to keep the ship on her course is abnormally large, which undoubtedly increases the resistance considerably. Because of this, the curves of C, as given in Fig. 12, should probably be modified to allow for more resistance than shown for the wind near the beam. This would reduce the valves somewhat for the relative wind abaft the beam. Allowing for the effect of the wind as given in the following table, it is seen that the power should be increased for the run of September 29 and decreased for that of November 17. From this the difference becomes 2,147 horse-power instead of 857 given by Mr. McEntee. The former seems rather high, and may be, but the important point is that the wind resistance should be considered, and since sufficient data are not available to determine it accurately, for this direction it appears that the analysis given in Table I by Mr. McEntee is not reliable. Since the effect of wind is present in Table I, it is not considered permissible to determine the wind resistance in Table II from it.

With respect to the resistance due to fouling as given in Table VII, this was taken from the curve in Fig. 4, Plate 4, which was experimentally determined in the Model Basin. It is fully understood that the rate of fouling and the resulting increase in resistance do not follow uniform curves, but in the absence of other data this curve was used, and the increase in wind resistance obtained happened to correspond with the previous value as determined from the trials of February 10 and 11, 1912.

It is of interest to note that the value of C as determined from Mr. McEntee's analysis agrees almost exactly with the experimental value as given in Plate 3.

$$C \text{ from analysis} = \frac{R}{V_r^2} = \frac{24{,}000}{(45)^2} = 11.85$$

$$C \text{ for experiment (Plate 3)} = 11.20$$

The relative velocity of 37.7 given by Mr. McEntee is V_c, the relative velocity along the course, whereas the relative velocity in the above formulae is V_r, the actual relative velocity (see Fig. 9, Plate 9). The latter is used here because it was adopted in the formulae for the determination of C, for the reason that it gave more consistent values.

The exact values of C are open to question and, as pointed out in the paper, it is not considered that the data presented fix them exactly. However, from prolonged observation of the ship's performance, and considering the conditions and observations made, it is believed that the values of C, determined from the performances under the most favorable conditions for these determinations, are more nearly correct than the experimentally determined valves and those derived from more or less unfavorable conditions.

It may also be noted that it is almost impossible to segregate the true wind resistance from the steering, sea propulsive efficiency, etc., under the actual conditions of observation, and for this reason the values of C represent the total effects, and not that of the wind resistance alone. This accounts for some difference between experimental and actual values.

TABLE I.—*Analysis of South Runs for Trials of September 29 and November 17.*

1	Date of trial	September 29	November 17
2	S = true speed, kn.	14.25	14.25
3	V_a = absolute wind velocity, kn.	35	25
4	V_r = relative wind velocity, kn.	26.9	23.6
5	α = absolute direction of wind, degrees	135—	112.5
6	θ = relative direction of wind, degrees	113	79
7	C = (corresponding to θ)	15	15
8	P_w = S.H.P. due to wind*	730	560
9	P_{wo} = S.H.P. due to wind in calm*	340	340
10	$P_{wd} = P_w - P_{wo}$ = S.H.P. difference between actual wind power and that in calm	1,070	220
11	S.H.P. measured by dynamometer	7,207	6,350
12	S.P.H. for calm	8,277	6,130
13	S.H.P. difference between two trials due to fouling	2,147	
14	Per cent of ideal power	35	

$$* P_w = \frac{C.V_r^2.S}{326.PC}$$

THE PRESIDENT:—A vote of thanks is extended to the author for his paper.

We are a little ahead of our schedule, and when we adjourn it will be for luncheon and to meet again at 2 o'clock. We will have no more papers until the afternoon session. If any gentleman has anything to suggest for the good of the Society, that he would care to have brought before the Council, we will be pleased to hear from him.

There being no further business transacted, the meeting adjourned until two o'clock.

SECOND SESSION.

THURSDAY AFTERNOON, NOVEMBER 15, 1917.

The Vice-President, Naval Constructor Richard M. Watt, called the meeting to order at 2.10 p.m.

THE CHAIRMAN:—By direction of his physician, our president has gone home to rest and to save himself for his arduous work of the morrow. He has done me the honor to ask me to preside.

Our next paper will be No. 6, entitled "Recent Developments in Tank Steamer Construction," by Mr. Robert W. Morrell, a member of the Society.

Mr. Morrell presented the paper.

RECENT DEVELOPMENTS IN TANK STEAMER CONSTRUCTION.

By Robert W. Morrell, M. E., Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

The growth of the American tank steamer fleet since the beginning of the European War has been so remarkable, and the tank steamers now represent such a large and important part of our merchant marine, that the construction of these vessels cannot fail to be a subject of interest in maritime circles.

At the end of the year 1914 the tank steamers under American registry numbered about 80 (exclusive of barges), of 278,837 gross tons and approximately 416,000 tons deadweight, which at the time represented only about 10 per cent of the total steel tonnage of the United States, excluding the Great Lakes and sailing vessels.

At that time shipbuilding in this country was almost at a standstill and the outlook was very gloomy. So complete was the cessation of activity in the shipyards that this period of depression may be said to represent the line of demarcation between the old shipbuilding era and the new.

Early in 1915 shipbuilding took on a new lease of life, and it is interesting to note that it was the construction of tank steamers which started most of the yards on their new road to prosperity. It was the need for oil carriers which rescued the shipbuilding industry and revived it.

Since the beginning of 1915 there have been built in this country 57 tankers (exclusive of barges), of 371,900 gross tons and 519,200 tons deadweight, thus more than doubling the American tank steamer tonnage. It will also be noted that the average tonnage of the individual vessels shows a great increase over that of the vessels previously built.

In addition to the extensive building program carried on, a marked addition to the American tanker fleet was made under the provisions of the Panama Canal Act of August 18, 1914, by means of which 40 foreign-built tankers, aggregating over 190,000 gross tons or 285,000 tons deadweight, have been transferred to American registry.

We therefore have the honor of displaying the American flag from the largest tank ship afloat—the German-built steamer Jupiter, now the Standard, of 10,073 gross tons and 17,000 tons deadweight. The second largest tanker is a British vessel of 15,500 tons deadweight, while the United States ranks third, having constructed a type of vessel of 15,000 tons deadweight. It might be mentioned that six vessels of this size have already been turned out in this country, and that four more are nearing completion.

Up to the present date we have lost six tankships through war causes. Two of these were German-built, three British-built, and one American-built. They represent a gross tonnage of 26,537 and 38,590 tons deadweight.

The total number of American tankers now in service is therefore about 170, having a total gross tonnage of 823,200 and a total deadweight carrying capacity of 1,180,000 tons. Thus it will be seen that during the recent period of activity the number of tankships has been increased 112 per cent, the gross tonnage increased 185 per cent, and the total deadweight tonnage increased 185 per cent. Not only is this the case, but it is also found that the tank steamer tonnage is now close to 20 per cent of the total steel American tonnage (exclusive of the Lakes), as against 10 per cent at the beginning of 1915, thus indicating that the greatest of the recent progress in shipbuilding has been in the construction of tankers, and that the growth of the oil industry has demanded for them a prominent part in our shipbuilding program.

In addition to this impressive fleet of tankers, we now have under construction in the United States a total of 64 tank vessels, representing 496,680 gross tons and 575,750 tons deadweight, marking the greatest shipbuilding activity in the history of the country. This recent construction on so large a scale could not fail to bring out interesting and instructive features deserving of comment.

The most impressive feature of the modern tanker is the size. Previous to 1915 the average deadweight was 5,200 tons, but the average deadweight of the vessels built in the United States since that time is 9,100 tons.

In 1915 the largest American tankers were the S. S. John D. Archbold and John D. Rockefeller, of 11,500 tons deadweight, but we have since built ten larger vessels, the largest of which attain a deadweight of 15,000 tons. The shipowner's faith in the economy of the large tankers therefore appears to be firmly established. In fact, under certain conditions, the large vessels, trading at ports having limited depth of water and therefore obliged to load part cargoes, have been able to compete with smaller vessels whose light draught permits loading full cargo.

Along with the increased size came the development of the shelter-deck type of vessel. The term "shelter-decked type," as commonly used in this country in referring to tankers, applies to a vessel having three continuous steel decks, the uppermost of which is the strength deck. According to Lloyd's Register, a shelter-decked vessel is one in which the uppermost or shelter deck is a light, continuous superstructure, with one or more tonnage openings. If without tonnage openings, it is an awning-decked vessel, while if the upper scantlings are heavier it becomes a spar-decked vessel. The commonly accepted use of the term "shelter-decked vessel" in this country, however, is in reference to any vessel having a continuous weather deck, as opposed to the type having raised forecastle, bridge and poop.

The first shelter-decked tankers built in this country were the sister ships John D. Archbold and John D. Rockefeller, of 11,500 tons deadweight each. These vessels had the oil tanks carried up to the upper deck, which is the next deck below the shelter deck. The oil hatches were located on the upper deck, and gas trunks

were built around the hatches and extending from upper to shelter deck, to keep the gases from permeating the 'tween-deck space.

Experience has proven these trunks a source of danger to the ships, as the heavy gases accumulate at the hatches and great caution is necessary to prevent men from being overcome when entering the tanks. Apparatus for clearing these spaces of gas has since been installed.

The next step in the development of the shelter-decked type was the carrying of the expansion trunks right up to the shelter deck. This was embodied in the Charles Pratt and subsequent vessels of that type with great success.

With this arrangement, the expansion trunk bulkheads extend from the second deck (or main deck or tank deck, as it is variously called) up to the shelter deck, thus making the expansion trunk two decks in height. The summer tanks are arranged outboard of the expansion trunk between the second and upper decks. The oil hatches for both main and summer tanks are located on the shelter deck, and small trunks, extending between the upper and shelter decks, are built for the summer tanks. Outboard of the expansion trunk, between the upper and shelter decks, are open 'tween-deck spaces above the summer tanks.

The principal advantages of this design over that in which the oil is not carried above the upper deck are as follows:—

1. An increase of about 10 to 15 per cent in the cubic capacity of the tanks is obtained, which is of great benefit when carrying light grades of oil.

2. The vessel can be trimmed when loaded with much better results, as the expansion trunk extending through two deck heights gives great scope for the desired ullages. If the vessel has a tendency to trim by the head when leaving port, on account of full fuel tanks forward, this can be overcome with the present design by leaving large ullages in the forward cargo tanks and smaller ullages in the after tanks. It is also possible, as fuel is used, to maintain any desired trim by transferring the cargo. The deep trunks allow great leeway in this respect.

3. On account of the oil hatches being on the shelter deck, the danger of getting gas in the 'tween-deck space is avoided.

4. The center of gravity of the cargo is higher, making an easier ship.

5. The expansion trunk and center line bulkheads, extended up to the shelter deck, provide valuable additions to the longitudinal strength of the ship.

To offset the above, it should be noted that additional steel is required to carry the trunks to the shelter deck and that the scantlings must be increased on account of the increased head of oil. Therefore a slight increase in the hull weight is involved, and, if the vessel is to carry only heavy crude or fuel oils, the extension of the oil space above the upper deck is not advisable. This brings out the fact, which is constantly cropping up, that to design the most economical tankers they must be specialized for particular trades and used in no other trades. The point just mentioned illustrates this—if the vessel is intended to carry light oils, the oil space should be made as large as possible by extending it up to the shelter deck; but if

intended to carry only heavy oil, large cubic space is not required and the oil space may terminate at the upper deck.

It should be noted in passing that with the oil hatches on the shelter deck it is not advisable to locate the living quarters amidships directly on the oil-tight deck. To overcome this, on all vessels of this type the accommodations have been raised 3 feet 6 inches off the shelter deck, leaving an open space under the house. The house plating is extended down to the deck on the front and sides, but is open for access at the after end. The house with this construction requires particularly secure fastening to the shelter deck.

It is impossible to avoid bringing up some of the valve operating rods into this space under the house, but these are extended out clear by means of bevel gears.

There have recently been built, or are now building, several shelter-deck vessels in which the oil hatches are located on the upper deck, and the 'tween-deck space is entirely open, without gas trunks, but the majority of the shelter-decked ships are now of the type just described, namely, with the trunk to the shelter deck. This type is highly satisfactory for an all-round tanker.

A recent special design which is worthy of note is embodied in the tanker D. G. Scofield, in which the entire 'tween-deck space, between upper and shelter decks, is made suitable for carrying case or barrel oil, in addition to the bulk cargo in the tanks. The oil hatches are on the upper deck and large cargo hatches are provided in the shelter deck each side of the center strake, which is continuous. Three masts are fitted with complete cargo handling gear consisting of booms and winches.

This is another instance, however, of adaptation of a tanker to special trade. Such package cargo handling equipment on the majority of tankers would be useless.

In considering the subject of shelter-decked tankers, the question naturally arises as to what determines whether a vessel shall be built with a shelter deck or a forecastle, bridge and poop deck. The answer is somewhat obscure, but the determining factors seem to be mainly matters of size and of personal preference. The dividing line seems to be in the neighborhood of 10,000 or 11,000 tons deadweight, the vessels above that size being, almost without exception, shelter-decked vessels.

The main point involved is one of draught. In increasing the size of the vessels it is not desirable to increase the draught in proportion. The shelter-decked type lends itself to carrying an increased deadweight on a limited draught without adopting extreme proportions. The shelter-decked type is also preferable for strength purposes in the larger sizes.

With regard to tonnage openings, a few shelter-decked vessels of this nature have been built, and they have the advantage of small tonnage measurement combined with good structural design due to small length to depth ratio; but the greater depth required tends toward a heavier ship.

For purposes of comparison I have made a rough approximation of the gen-

eral characteristics of four steamers, each of 11,000 tons deadweight capacity but of different types, as follows:—

1. Shelter-decked vessel with expansion trunk carried to shelter deck.

2. Shelter-decked vessel with oil space up to upper deck only; no tonnage openings.

3. Same as (2) but with tonnage openings.

4. Forecastle, bridge and poop type.

In working out the dimensions the length and beam were kept constant and the depth and draught allowed to vary to suit the different conditions.

The following table gives the results of the calculations, which have not been carried out to any degree of refinement but which are sufficient to indicate what may be expected of the different types:—

COMPARISON OF FOUR TYPES OF TANKERS OF 11,000 TONS DEADWEIGHT EACH.

Type	L.	B.	Draught	Depth to upper deck	Depth to shelter deck	Displacement	Weight of ship light	Cargo capacity	Gross tonnage
	Feet	*Feet*						*Cu. feet*	
1	450	59	26′ 4″	28′ 0″	35′ 6″	16,270	5,270	483,000	7,900
2	450	59	25′ 6″	27′ 10″	35′ 4″	15,700	4,700	420,000	7,850
3	450	59	26′ 0″	31′ 0″	38′ 6″	15,800	4,800	458,000	7,750
4	450	59	26′ 6″	34′ 0″	.....	16,000	5,000	460,000	7,850

From the table it will be noted that type 1, although a heavy ship, has great cubic capacity and is therefore best adapted to carrying light grades of oil. Type 2 is a lighter ship, for reasons previously explained, but has small cubic space and is therefore suitable only for heavy oil trade. Type 3, on account of the tonnage openings, requires great depth, resulting in increased weight of hull and increased cubic capacity. Type 4, it will be noted, requires greater draught and is rather heavy but has plenty of room inside.

It must be remembered that all of these vessels will carry a deadweight of 11,000 tons, and therefore the variations and possibilities with the deadweight fixed, and even with length and breadth fixed, are apparent. The results go to show that the vessel when designed must be made to conform to the conditions under which it is intended to operate.

In the matter of cubic cargo space, for instance, let us assume that for a vessel of this size the fuel carried will be 1,050 tons, with 250 tons fresh water, stores, etc. This leaves 9,700 tons for cargo, which, if heavy fuel oil, occupies 358,900 cubic feet; if refined oil, 436,500 cubic feet; and, if naphtha, 485,000 cubic feet. A study of these figures will readily give an indication of the respective capabilities of the vessels.

The foregoing types were assumed to have the usual sheer line, the middle

portion of which, if faired on the three-quarter-inch lines, would show an easy curve. It must be noted, however, that there is a growing tendency at present to adopt a straight sheer line amidships, and in fact there are tankers now under construction embodying this idea.

In order to investigate the effect of the straight sheer, the sheer line in type (1) was changed and made straight for 55 per cent of the length amidships, fairing in to the original height at the ends. This change made an increase in the moulded depth to shelter deck of 2¾ per cent. The principal objection to the straight sheer is the reduction in height of shelter deck for a space beginning at the stem and extending to a point about 35 per cent of the length abaft the stem, where the old line crosses the new. The greatest reduction in height occurs between 15 and 20 per cent of the length abaft the stem. The reduction amounts to only a few inches and is not a serious difficulty.

With the new sheer line, the allowable draught will not be noticeably changed, and the difference in hull weight will be negligible.

The advantage structurally of the straight sheer is obvious, as it will permit practically universal work throughout almost the entire length of the oil space, and the frames, bulkheads, etc., will be alike for every tank except the end ones.

A prominent feature of recent construction has been the subdivision of the cargo tanks into groups for the carrying of different grades of oil. If two different grades are separated by a single bulkhead there is danger that a leak in the bulkhead, permitting a mixing of the grades, will spoil the cargo. The first step was to place the pump room amidships, which, aside from being a most convenient location for pumping, divides the tanks into two groups in which different grades of oil can be loaded without danger of mixing.

This was carried further and cofferdams inserted between the tanks. The 15,000-ton deadweight tankers previously mentioned have ten main cargo tanks divided into three groups with a separate pumping system for each. Several smaller tankers have similar divisions.

This is another example of the incorporation of special requirements for special trade. As an extreme case, there is one vessel now building on the Atlantic coast which has five cofferdams and a pump-room dividing the cargo tanks into four separate blocks. One of the cofferdams, however, is located between the after fuel oil tank and the fire-room. Many of the modern tankers have this arrangement, which is a wise safety precaution originated on account of fires started by oil in the fire-room due to leaky bunker bulkheads.

Where such cofferdams are built, they are provided with tunnels for use in the event of the vessels burning coal. The tunnels are blanked by oil-tight bolted doors on each end, but if used for coal the oil-tight doors will be removed and vertical sliding bunker doors fitted. The fuel-oil piping passing through the cofferdam is fitted with a valve on each bulkhead, the valve on the bunker side being controlled from the deck. The cofferdam is also provided with a sea valve controlled from the deck, for flooding in case of fire. Thus, if a fire originates in the

boiler-room, it can be isolated from the fuel supply, while if the fire starts in the tanks the propelling machinery can be kept intact.

An important feature of the tank steamer situation is the construction of steamers with cylindrical tanks. Six of this type of vessel have been built or are being built by the Chester Shipbuilding Company. Aside from the saving in hull weight in this type, it has the advantage that the cylindrical tanks can be constructed by people other than shipbuilders. Under the present conditions this fact bears considerable weight. The present design shows a series of tanks the diameter of which is as great as the vessel's framing will permit. A recent design which places smaller tanks on opposite sides of the center line appears to have an advantage with regard to preventing listing of the vessel.

If it is desired to carry cargo or ballast outside the cylinders—that is, between the cylinders and the ship's sides—it is important that the head of water or oil outside the cylinders be not greater than that inside, and for this purpose automatic non-return valves are provided.

The cylindrical tanks are particularly well adapted to conversion jobs, and the few recent conversions of general cargo vessels to tankers have been on this basis. It is a remarkable fact, in view of the great demand for tank tonnage, that so few vessels have been converted to bulk-oil carriers, and rather reflects the skeptical attitude of the shipping community toward converted vessels.

Returning to the ordinary tanker and coming down to structural features, it appears that the greatest single item which made for better construction has been the adoption of rolled tee-bar section for oil-tight work.

Until recently, tee-bar was not generally rolled for ship use and was unobtainable in proper sizes. Under pressure from shipbuilders and shipowners, however, the mills have adopted this section in several sizes, and the advantages of its use in the construction of tankers are generally recognized.

Tee-bar is now being used for the bracket connections of longitudinals to bulkheads, and is replacing single and double-angle connections for this purpose. It has the advantage of being made oil-tight much more readily than the angle connections, for the double-angle clips have a habit of leaking at their ends, and the single-angle clip gives difficulty along its heel.

The usual size of tee-bar for bracket connections is 6½ inches by 6½ inches by .45 inch, double riveted in both flanges. Where this replaces a single-angle clip 3½ inches by 3½ inches, single riveted, it is apparent that an equal number of rivets can be obtained in a much shorter tee-bar clip. It is inadvisable, however, even with equivalent rivet connections, to reduce the depth of the brackets on account of using shorter tee-bar clips; and the tendency is therefore to use longer tee-bar clips than the riveting requires in order to maintain the effective portion of the brackets.

A further use of tee-bars is for bounding connections on oil-tight work. On some of the shelter-decked tankers just built, in which the expansion trunk is carried to the shelter deck, the bar is used to connect the upper-deck plating to the

expansion trunk bulkheads, with excellent results. If a single angle were used instead, the heel would require to be caulked for the entire length.

Tee-bar is also being used to connect the top of the fore deep tank (under the forward hold) to the fore-peak bulkhead and to the forward cofferdam bulkhead. The shell connection, where the heel need not be caulked, is angle bar, and this butted against the tee-bar and straps fitted.

The Sun Shipbuilding Company is using tee-bar for the boundaries of the transverse oil-tight bulkheads, and, while the writer has approved this as an emergency measure, there is some question whether double bounding angles are not necessary to maintain proper oil-tightness.

The use of the tee-bar for bilge-keel attachments has long been established as the only thoroughly satisfactory connection, and recent experience has indicated that these tee-bars should be at least 9/16-inch thick.

One other feature is of great importance for oil-tight work, namely, the multiple punch. This has not been used extensively up to the present, but its possibilities are so great that it is believed this machine will soon be in common use in building tankers.

The first requirement for oil-tight work is that the rivet holes shall be fair—a result which, unfortunately, is not always obtained with the common single punch, especially when operated by a gang on piece-work.

By using the multiple punch, the holes are spaced mathematically correct; every space is exactly the same as every other one, therefore the holes cannot fail to match when the work is erected. If, therefore, the multiple punch will insure fairness of holes, its importance for oil work is obvious. In addition to this advantage, the actual cost of punching, reaming, riveting and testing will undoubtedly be lowered, while the actual laying-off of the work for punching is entirely eliminated where this punch is used.

It must be understood that this type of machine imposes severe restrictions on the rivet-spacing, and it is only by painstaking care in the original design and in developing the riveting details that the multiple punch can be used. The chief difficulty is that the spacing in frames or longitudinals must be exactly twice that in seams and butts, which may involve some additional rivets not required by the rules. The spacing in way of bulkheads and transverse frames presents a knotty problem, and it may be that some holes will have to be single punched or drilled.

The multiple punch is of course only suitable for work on the dead flat, but if properly worked out it can be used on a very large portion of such work and will result in making the parts universal to a far greater extent than at present.

In view of the large number of tankers recently sunk by submarines, many of which have been in ballast, considerable thought has been given to the question of ballasting in order to give the most favorable conditions if torpedoed. The ballast condition of a tanker is a variable quantity as it may be altered at will to suit weather conditions or for other reasons.

Many claim that if all tanks are filled with water to bring the ship to her load

draught and several tanks are then pierced by explosion, the condition of trim and list will be changed but little, whereas if some of the tanks are empty and then pierced the vessel will settle, due to filling the tanks previously empty, and will list as well, due to the additional water on one side only.

On the other hand, if water is carried in all the tanks, obviously some of them must be slack tanks and be even more likely to cause listing.

After carefully considering the subject, the writer's conclusions are:—First, that no slack tanks should be carried, thereby eliminating this danger from listing. Second, that the vessel be given as much reserve buoyancy as possible, which may be the means of saving the ship if torpedoed in the machinery space; therefore as little ballast should be carried as weather conditions will permit, but whatever is carried should be in full tanks so distributed as to equalize the loading to best advantage. Third, that gate-valves be fitted in the center-line bulkhead near the bottom of each tank, operated from the deck, but left open at sea; thus, if empty tanks are pierced, the water will equalize and prevent listing.

Experience indicates that a torpedo explosion shatters the structure in the vicinity and renders it non-watertight or non-oil tight for a considerable radius. If several tanks are full, the water or oil in them, being practically non-compressible, transmits the shock and destroys the watertightness for a much greater radius. This is another reason for having empty tanks. If the shock of explosion is so transmitted by water in the tanks as to cause the fuel-oil bulkhead to leak into the fire-room, the ship is doomed; therefore anything making this a possibility must be avoided.

With reference to the subject of standardizing, this is a matter which has been in the air for some time, and the standardization of tankers has been discussed on many occasions.

So far as the standardization of fittings is concerned, there are great possibilities in this direction. It is understood that the Bethlehem Steel Corporation has already taken steps to standardize fittings in its various plants, and it is to be hoped that this will include fittings for tankers, such as oil-tight hatches, shell manholes, tank ladders, cargo pipe fittings, valve operating gear, heater coils, gas vents, etc. It would be of great advantage if standard fittings of this nature could be adopted by all the shipyards in the country.

As to standardizing tankers themselves, it would be interesting to note that the 64 tank vessels now under construction in American yards represent nineteen distinct types or designs and are being built in sixteen different shipyards for sixteen different owners, considering vessels building for "foreign account" as being under one owner. At least there were sixteen different owners prior to August 3, at which time all these vessels were requisitioned by the United States Shipping Board, Emergency Fleet Corporation. The construction of these vessels is now in the hands of the Corporation, represented by the district officers; at the urgent request of tank-ship owners, the district officers have retained the services of the

former owners' inspectors, in order that inspection by men thoroughly trained in oil-tight work might be assured.

The nineteen types above mentioned range in size from 5,000 tons to 15,000 tons deadweight and represent almost every possible variation in design. They were designed by competent men to meet specific requirements. Practically every oil company and every shipyard has its own standard type of tanker, or in many cases three or four standard types, all varying in accordance with the different needs of the business and with the different ideas as to how these needs are best met.

It has already been pointed out that special vessels are required for special trades in order to obtain the best results. A vessel designed to carry heavy oil is not suitable for transporting refined oil, and vice versa. A vessel designed for straight cargo is not suitable for a mixed cargo, but a vessel designed for mixed cargo is needlessly complicated and expensive for shipping straight cargo. Owners trading on the west coast only naturally desire to take advantage of the deep water to adopt wholesome proportions of length to depth, whereas other owners, trading in ports where draught is restricted, must adopt different proportions. Some trades require vessels with fuel capacity for ten days, others for forty days. In many cases large vessels are the most economical, but large vessels cannot be built in all yards and cannot enter all ports.

It is obviously impossible to find a single vessel to meet all requirements, and if an attempt at a compromise is made it will place practically every oil company at a disadvantage in having to operate vessels which are not quite suitable.

The nearest approach to efficient standardization would be in the adoption of at least four standard designs, consisting of two vessels, a large one and a small one, for the sole purpose of carrying cargoes of heavy oil, and two vessels, a large one and a small one, especially for carrying mixed cargoes of light oil.

In carrying heavy oil, such as fuel oil or crude oil, it is possible to load different kinds in the same vessel without danger of mixing, due to leakage or due to pumping one kind through the same pipe line as another. Therefore there is no need of subdividing the tanks for different grades.

The smaller vessel for this purpose would naturally be of the forecastle, bridge and poop type, and the larger one of the shelter-decked type. In both cases small fuel tanks for bunker use are sufficient, as it is possible for a long voyage to carry half a main cargo tank of fuel, or to carry it in summer tanks. The permanent fuel-oil tanks should consist of a short tank at the forward end of the cargo tanks, and another at the after end, thus enabling the vessel to be trimmed as the fuel is used. With this arrangement no cofferdams whatever are required in the vessel. The pump-room in this type of vessel should be located between the after-fuel tank and the boiler-room, thus separating the oil from the fires, and should contain the fuel-oil pumps and heaters as well as two cargo-oil pumps. A simple system of cargo-oil piping whereby both pumps can draw from the tanks

and discharge overboard independently is sufficient. The summer tanks may be fitted with drop-valves, connecting them with the main tanks, or they may be piped for fuel oil, as conditions require. All tanks in these vessels should be fitted with heater coils.

For the standard vessels intended to carry mixed cargoes of light gravity oils, the smaller would be of the forecastle, bridge and poop type and the larger of the shelter-decked type with expansion trunks carried up to the shelter deck. In both vessels rather larger fuel-tank capacity is required. On account of the danger in carrying naphtha next to fuel oil, cofferdams should be provided at each end of the cargo tanks. The cargo pump-room should be located amidships, thus dividing the cargo tanks into two groups. For safety, a cofferdam between the after fuel tank and the fire-room should be provided and the oil-burning apparatus installed in a separate enclosure in the fire-room wing. A fuel pump is required forward to transfer fuel aft from the forward tank. The cargo oil-piping system should permit of the pumping of different grades of oil from the forward and after groups of cargo tanks simultaneously and independently, without the two grades using any piping in common. The cargo piping must not extend into the fuel tanks. The summer tanks should be piped separately. Special precautions against gas must be provided, and the gas vents from the tanks fitted with automatic relief valves. Special ventilation for the pump-room and cofferdams must be furnished.

The foregoing outlines briefly the minimum that could be expected in the standardization of tankers. Assuming, however, that such standard designs were prepared and approved, it is not clear just what would be gained by throwing out all the present designs and adopting new standard designs. The vessels now building were designed especially for certain definite purposes, best known to their original owners, and it is not likely that standard designs would serve such purposes any better. The ships now building are duplicates of other ships previously built in the same yards, and the experience gained on the previous vessels is an asset not lightly to be ignored. The advantage of having all plans, material orders, templates and patterns for existing vessels places a handicap on standard ships which will take time to overcome, and the result would be to slow up construction instead of speeding up.

Unquestionably, the quickest and most enconomical means of building additional tankers is to duplicate existing vessels, for which the designs are already perfected and which conform specifically to the needs of the oil business. In this way only can the cheapest and quickest construction and the greatest economy of operation be attained.

The future tankship construction is, however, an uncertainty. All of the vessels now under construction are for 1917 or 1918 delivery. When these vessels are completed, the building of tankships will, according to present indications, be at a standstill in this country. So far as we are aware, the United States Shipping Board has not, up to the present time, made any provision for tankers in its ship-

building program. The board is promoting the construction of a huge fleet of cargo carriers to transport supplies to our allies and to handle the nation's increasing commerce; but it has entirely ignored one of the most important of the Allies' necessities and one of our own principal industries in excluding tankers from its program.

The nation's oil business has advanced with enormous strides and is still advancing. The demand for tank-steamer tonnage is greater than ever, and new vessels will be needed constantly to meet the ever-growing transportation requirements. We have lost many tank ships through war causes and will undoubtedly continue to lose them. In spite of all this, there is no provision for future requirements.

Oil companies and shipbuilders have endeavored to obtain the board's permission to proceed with tankship construction, but up to date this permission has not been granted.

The present situation is, therefore, that the Shipping Board is placing no new orders for building tank-ships and will not permit anyone else to do so. This policy can have but one result, and, if immediate steps are not taken, we shall unquestionably be faced by grave shortage of tank-steamer tonnage.

This condition is most serious and urgent and demands the earnest consideration of all shipping men having the nation's welfare, and the cause in the great struggle which it represents, at heart.

DISCUSSION.

The Chairman:—Before we proceed to the discussion of the paper which has just been presented by Mr. Morrell, one of our members, who has a business engagement this afternoon, desires to present a matter for informal discussion, and I am going to ask Mr. Walter M. McFarland, our vice-president, to take the chair.

(Vice-President Mr. Walter M. McFarland in the chair.)

The Chairman:—Gentlemen, this is a social matter, and one of a somewhat delicate nature, but one where there is a chance to pay a compliment and to do a very gracious act. The matter was brought to my attention by Mr. Wetherbee, and I think perhaps the quickest way to bring it to your attention would be to ask Mr. Wetherbee to state the case.

Mr. Charles P. Wetherbee, *Member of Council*:—Mr. Chairman, it was brought to my attention at lunch time that a large number of naval officers in uniform will undoubtedly be present at the dinner to-morrow evening, and there is a naval regulation which prohibits a naval officer from either taking a drink of intoxicating liquor, or being offered one, when he is in uniform. I am sorry, but that is the fact. At the dinner to-morrow even-

ing it will make a very awkward situation if the civilians are freely using alcohol in any form and these officers are not permitted to join with them. The question is whether or not it is not advisable to have a dry dinner, and I think that a discussion of this matter should be brought out now.

THE CHAIRMAN:—The object of bringing this matter up is to get an expression of opinion from those present. Naval officers, it would seem, are almost excluded from the discussion—perhaps they would hardly care to say anything, anyhow—but I hope that the civilian members of the Society will get up and express an opinion on the matter, because if we get something like a consensus of opinion, we will know what is best to do. If we see that there is a general feeling that it would be best to make it a dry dinner, that can be arranged for, and we will make it a dry dinner. On the other hand, if we find that there is a strong objection to that, we will have to give the matter further consideration.

MR. HOWARD C. HIGGINS, *Member of Council:*—Why does not Mr. Wetherbee put that matter in the form of a motion?

MR. WETHERBEE:—I am willing to put it in the form of a motion, Mr. Chairman, but you can do it so much better than I can, that I suggest you do it.

THE CHAIRMAN:—Mr. Wetherbee makes the motion that it is the consensus of opinion of those present that it would be desirable on the occasion of the banquet on Friday night to have everybody abstain from the use of wines and other liquors, on account of the presence of our dear friends and members in uniform, who are prohibited by law from indulging in intoxicants while in uniform.

The question is open for discussion.

Calls of "Question, question."

PROFESSOR H. C. SADLER, *Member of Council:*—I suggest that the matter be laid over until to-morrow, for the reason that we will have a larger number of members present then, and we can get the ideas of a greater number.

THE CHAIRMAN:—We will make a start and get an opinion from those present now. If we find the opinion is strong now, it will help to-morrow.

MR. R. R. ROW, *Member:*—I agree with what Mr. Wetherbee has suggested. We expect to have at our table two officers, quartermasters, from Hoboken, who will be abstainers —the Army as well as the Navy are subject to that law.

THE CHAIRMAN:—You are stating what we all know. What we want to know is whether you are in favor of having our banquet a dry dinner.

MR. HIGGINS:—I cannot see how there can be two opinions on this question. If the vote is called for, I shall vote "aye" to make it a dry dinner, out of compliment to the officers in uniform. What else can we do?

NAVAL CONSTRUCTOR RICHARD M. WATT, *Vice-President*:—I feel sure the officers in uniform will not want to interfere with the pleasure of our invited guests.

THE CHAIRMAN:—We know that—we do not want you people to say anything—we know that.

MR. WETHERBEE:—I recognize the fact that it is perfectly possible to have a mixed affair, but it would be probably somewhat embarrassing.

THE CHAIRMAN:—The idea is that it would be paying a delicate compliment to the men in uniform. And to my mind it is a very beautiful thing, that the people who would ordinarily indulge are willing to refrain, as a compliment to the officers present, and I think it is very creditable to those who have suggested it. Do we find there is a large sentiment in favor of having a dry dinner?

MR. A. GEORGE MATTSSON, *Member*:—I think we as engineers should give a good example to the balance of the nation, and I think we should be the first ones, at a public function such as our banquet, to set the example of having a dry banquet.

MR. HERBERT L. ALDRICH, *Associate Member of Council*:—I hope that there will be a dry dinner out of compliment to the officers.

PROFESSOR GEORGE F. CROUCH, *Member*:—I agree with the other members who have spoken in favor of having a dry dinner. I certainly think it would be the finest sort of compliment we could pay to our associates in uniform.

THE CHAIRMAN:—I would like to hear a number of the gentlemen speak. We can take the vote later. Have you anything to say, Mr. Smith?

MR. WILLIAM W. SMITH, *Member*:—I have nothing to say.

THE CHAIRMAN:—Like myself, you are an ex-officer, and can say what you think about it.

MR. LINDEN STUART, *Member*:—There is no question in the minds of most of us that this is the right thing to do. However we may feel about our own individual rights in the matter, it is the right thing for us to abstain from indulging in wines or liquors at the banquet.

THE CHAIRMAN:—All of the expressions of opinion having been one way, it is hardly worth while to prolong the discussion any further. We have asked for free discussion. If you are ready, we will put the question to vote.

As you understand, this vote will merely express the consensus of opinion of this meeting, and the matter will have to be taken up further with the Council, which will take the necessary steps to carry it out. This is merely an expression of opinion of those present. The question is "That it is the consensus of opinion of those present at this meeting that out of compliment to our officer members who cannot indulge in wines that the dinner be made

a dry dinner." All in favor of the motion say "Aye"; contrary minded, "No." It is unanimously carried.

Vice-President Naval Constructor Richard M. Watt then resumed the chair.

THE CHAIRMAN:—You have all heard the reading of the paper entitled "Recent Developments in Tank Steamer Construction." Undoubtedly our enemy recognizes the importance of the tank steamer, because it would seem that particular efforts were directed towards the destruction of this type of steamer. I hope that the members here present also recognize the importance of the tank steamer and that we may have discussion of the paper.

If there is no discussion of the paper—and it is important and certainly justifies discussion—I will express to the author of the paper the thanks of the Society for its preparation. It is hoped that there may be some communicated discussion.

The next paper on our program to be taken up at this session is No. 7, entitled, "Power and Economy Tests of the S. S. Pontiac," by Messrs. A. George Mattsson, Member, and Thomas Durkin. Mr. Mattsson will present the paper.

Mr. Mattsson then presented the paper.

POWER AND ECONOMY TEST OF THE S. S. PONTIAC.

By A. George Mattsson, Esq., Member, and Thomas Durkin, Esq.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

In view of the fact that a dozen or more ships, duplicates of the Pontiac, have been completed this season and last, both the Great Lakes Engineering Works and Cleveland Cliffs Iron Company, respectively, builders and owners of said steamer, deemed it advisable to have the Pontiac thoroughly tested as to speed and economy; all the more so as this class of freighter is being adopted as a standard with the present depth of channels and height of ore-loading docks. It is considered the most practical as well as profitable carrier in the iron ore trade now on the Great Lakes.

The Pontiac is a bulk freighter of the following principal dimensions:—600 feet overall, 580 feet keel, 60 feet beam and 32 feet deep, and is constructed on the arch girder and transverse frame system with straight hopper sides 6 feet deep from the skin of the ship, extending up to the main deck stringer. This space is used for ballast in addition to the ordinary water bottom, which is 5 feet 6 inches deep, giving a total water ballast capacity of 7,300 net tons. This ship is of the single-deck type, having a main deck at the ends only, and her cargo space is free from any obstruction whatsoever.

The spar deck has 18 hatches, 12 feet fore and aft, 38 feet wide and 24 feet centers.

MACHINERY.

The engine, placed aft, is of the well-known Great Lakes standard design with cylinders 24½ by 40 by 65 inches diameter and 42-inch stroke. The low power cylinder is placed forward, the high power cylinder in the middle and the intermediate aft; sequence of cranks, high power, low power and intermediate.

The high power and intermediate cylinders are fitted with piston valves and the low power with triple-ported slide valve. All ports and passages are proportioned for a piston speed of 600 feet per minute.

The air pump, of Edwards type, is 39 inches in diameter by 14-inch stroke, driven from the high power cylinder crosshead; one bilge pump 5 inches diameter by 12-inch stroke and one cold water pump 3½ by 12 inches are worked from the air pump beam.

The condenser is of the injection type as customary in the Great Lakes. The main shaft is 12¾ inches in diameter, thrust shaft 12¾ inches and the outboard shaft 14 inches in bearing. The propeller, of the sectional type, is 15 feet in diame-

ter by 13 feet 9 inches pitch at the tip, the four blades having a developed area of 83 square feet.

AUXILIARY MACHINERY.

One feed pump of the simplex, double acting, pot-valve type, 12 inches by 7½ by 16 inches; one fire pump of the duplex, double acting, pot-valve type, 12 by 6 by 12 inches.

One sanitary, one fresh-water and one mate's pump of the duplex, double acting, pot-valve type, 6 inches and 4 by 6 inches. All the above pumps are horizontal and outside packed.

Ballast pumps.—To handle the great amount of water previously mentioned in six hours, four pumps are installed—two 15-inch centrifugals direct-driven by double, vertical engines, and two horizontal reciprocating pumps, 8 by 12 by 14 inches, all working in unison by means of one double manifold connected to all compartments.

ELECTRICAL GENERATORS.

Two 15 kilowatts each, driven by a 7 by 7-inch vertical engine and one 5 kilowatts driven by a 5 by 5-inch vertical engine, wired to all living quarters, machinery space and also to all parts of the cargo hold. One all-round steam steering engine, geared direct to the quadrant.

DECK AUXILIARIES.

Six mooring engines of regular size; two smaller ones for handling the hatch covers. One windlass.

BOILERS.

Three in number, of the cylindrical type, 13 feet 6 inches inside diameter by 11 feet 2 inches long overheads; each fitted with two corrugated, Morrison furnaces 50 inches inside diameter; 294 tubes, 3 inches external diameter and 7 feet 8 inches long between tube plates, built according to U. S. Government rules for 180 pounds working pressure. The grate bars are 5 feet 6 inches long with Sturrock patent bridge walls, 12 inches high from the grate.

Total heating surface of the three boilers is 6,405 square feet and total grate surface 137¼ square feet. These boilers are worked under the improved Great Lakes Engineering Works system of heated positive draft. The fan supplying the necessary air for combustion is of the Sirocco type, has a fan wheel 36 inches in diameter by 18 inches face, driven direct by a 6 by 6-inch vertical engine. The suction air duct is extended into the fire-room to give improved ventilation there. The boilers are also equipped with mechanical flue blowers, arranged so that the tubes in the boilers as well as air heater can be thoroughly cleaned at any time.

Other important features of the boiler room installation are:—the closed feed water heater of the S & K type, through which the exhaust from all the auxiliaries passes. The feed water, after being forced through the heater tubes, is dis-

charged into the vertical purifiers of the Learmonth type, one for each boiler, with the result that the boilers are thoroughly clean.

Two 6-inch compound hydraulically operated ash guns are located on the forward bulkhead of the fire-room, as a speedy and convenient method for discharging the ashes.

It is worthy of note that the crew, privileged to work in the fire-room, do so in ample and cool quarters, contributing considerably to the good results obtained.

TEST.

The object of this test was to ascertain the speed, with full cargo, on Lake Huron from Detour Light to Fort Gratiot, a distance of 225 statute miles. The fuel being of a good quality, it was decided to run with maximum power and to collect all data regarding the economy of the propelling machinery under these conditions. To that effect the valve motion was thrown in full gear and steam kept steadily at allowed pressure. Coal and ashes were carefully weighed for six hours, which coincides with the watches in the fire-room. The water level in the boiler, 4 inches in the glass, remained constant during the entire test. Six fires were cleaned and the flue blowers operated once as customary, during the six hours.

The Orsat apparatus was used freely, showing an average reading of 14 per cent carbon dioxide (CO_2), proving not only that the fires were kept in good condition but also that a small additional amount of air, introduced above the grate, would have been beneficial.

Indicator cards and temperature of feed water, air heaters, ash pits, etc., etc., as well as air pressure, were taken hourly.

The six-hour economy test was accomplished mostly during daylight, and the only auxiliaries in use were the fan engine, feed pump, the 5-kilowatt generator and the fire pump, only when ashes were sent overboard.

The weather was ideal, very little wind and sea, and the 12½-mile speed down Lake Huron was maintained. The steam pressure never varied and due credit is given the intelligent work of the firemen.

The compiled data are given in the accompanying tabula and the general result only is repeated:—

Speed 12½ miles per hour (10.875 knots).

Coal per hour as fired, 3,265 pounds.

Coal per indicated horse-power per hour, 1.34 pounds, which proved that with ample heating and grate surfaces, together with a good quality of fuel, the economy, as expressed in coal per indicated horse-power, is as high with full power as with lesser.

Indicated horse-power, 2,441; 17.78 indicated horse-power per square foot of grate; 23.8 pounds of coal per square foot of grate.

This result was accomplished with slightly less than 1 inch air pressure at the fan and an average of .48-inch in the ash pit.

Admiralty coefficient, 351.

The machinery worked splendidly, boilers and all piping perfectly tight throughout the ship, and the performance on the whole was to the entire satisfaction of the owners.

In addition to the paper as above, the authors present the following addendum as a discussion for the purpose of securing information from the members on the question of feed pump efficiency.

In connection with the power and fuel test it was desired also to have data on the efficiency of the boilers and no apparatus being available to weigh the feedwater, the displacement of the feed pump was used to measure same; to that effect the valves were carefully ground and made tight previous to the test, feed pump plunger and stroke were carefully calibrated, number of strokes measured by revolution counter, and the following result was obtained:

Feedwater per hour (assuming 6% slip)	37,758 lbs.
Water evaporated from 186° per lbs. of coal	11.56 lbs.
Equivalent water evaporated from air at 212°	12.48 lbs.
Water evaporated from 186° per lbs. of combustible	12.66 lbs.
Equivalent water evaporated from air at 212°	13.68 lbs.
Efficiency of boiler	81 per cent
Efficiency of boiler and grate	88 per cent
Feedwater per indicated horse-power per hour, main and auxiliary engines	15.47 lbs.
Feedwater per indicated horse-power per hour, main engine only	15.22 lbs.

DISCUSSION.

THE CHAIRMAN:—This paper entitled, "Power and Economy Tests of the S. S. Pontiac," is now open for discussion.

PROFESSOR HERBERT C. SADLER, *Member of Council:*—Gentlemen, I do not know that there is very much discussion to be made on this paper, but I would like to thank Mr. Mattsson for the complete results that he gives. We sometimes get results of tests reported in our Transactions that are not complete, and some of us have found in trying to utilize that data later, that certain things have been left out. I am sure our thanks are due to the Great Lakes Engineering Works and to Mr. Mattsson for giving us such complete information on this particular test.

It is also interesting to note that our friends on the lakes do take some interest in the rather refined part of the profession, notwithstanding the criticisms that are sometimes made by our friends on the coast. On the lakes just as much minute attention is paid to the latest developments in the engineering profession and the securing of the maximum efficiency in

engines and boilers as anywhere else. A boiler efficiency of 81 per cent is, of course, very good—perhaps too good. There is no question but what that is obtained from the figures as given, but I think it is a little dangerous to take the feedwater from the measurements of the feed pump.

Mr. Mattsson:—I wish to say that those figures are not part of the paper proper—they are printed after the paper as an addition or addendum. Before sending it in I asked the builders of the feed pump what they thought the slip would be and they said that 6 per cent would be a fair figure for this particular pump. On the other hand, if there is 10 per cent slip, of course the result would be different. At any rate, I felt quite sure that this addendum would arouse considerable discussion.

Mr. Walter M. McFarland, *Vice-President*:—I have only a word to say—I am very sorry to have to criticise the paper of my friend Mattsson at all, but his figures show an impossible efficiency in the case of this boiler. If I could find a boiler with an efficiency of boiler and grate of 88 per cent, I would try to get my company to buy it at almost any price. Mr. Mattsson as an expert knows that 88 per cent is absurd and impossible, and he knows also that a six-hour test is rather uncertain, however great the care taken to get the data accurately. As Professor Sadler says, when you have to get your water by taking it from the strokes of the feed pump, that takes away any idea of accuracy whatever.

If we are to take this paper as a desire to give some information, we should be grateful to the authors for bringing this matter before us, but I merely feel that we ought not to let this pass, and let this point of efficiency stand as stated by Mr. Mattsson.

Mr. Mattsson:—In that respect I would say that we repeatedly measured the stroke of the feed pump; of that I am quite sure. It had a counter connection giving the exact number of strokes, but we are not sure how tight the valves were, and I called up the agent of the Blake people to see if he could come up here this afternoon. Is there a representative of the Blake people here, Mr. President? I requested him to come up and give light on that subject, because I knew it would be brought up in discussion.

Mr. McFarland:—I think if Mr. Mattsson will take the stack temperature and figure out the percentage of the total combustion that went up the chimney, he will find that he would not have 88 per cent left. There has been no heat balance made, and until that is made you cannot learn anything about it positively. It would be rather extraordinary that in such an offhand test as this the world's record for efficiency would be beaten. No boiler test, under accurate conditions, has shown an efficiency for marine practice above 80 per cent, even with oil fuel. When you come to coal fuel, if you get 74 or 75 per cent, you are doing extremely well. This 88 per cent is away above the results heretofore secured in a boiler oil-fired or gas-fired, or fired in any other way, and manifestly it must be inaccurate.

Mr. Mattsson:—That is not part of the paper.

Mr. McFarland:—We could not let this go by without calling attention to it. If a star was put before the efficiencies, and attention called in a footnote to the fact that these efficiencies were based on feedwater measured by the feed pumps, in a six-hour test, etc., then

everybody would see it carried that degree of unreliability, but to have it, as it stands, in the form of a naked statement of 88 per cent efficiency, should not be allowed to pass without pointing out its impossibility.

Mr. William W. Smith, *Member:*—In regard to measuring water by means of a boiler feed pump, I have tried this method. The length of stroke of the pump was measured and I found that there was a variation of anywhere from 7 to 15 per cent, and that the accuracy of measurement was not within approximately 20 per cent of the correct value. We measured the water discharged by the pump in a measuring tank, and found that the results were very erratic and could not be depended upon at all.

Professor Goold H. Bull, *Member:*—I ask Mr. Mattsson how he got his differentiation between total feedwater and the feedwater of the auxiliaries. It is stated in pounds, and there is no record of how it was obtained.

In regard to auxiliaries, we know that auxiliaries consume anywhere from 40 to 120 pounds of water per horse-power hour. I have seen direct-connected engines that would require 120 pounds per horse-power hour, direct connected with the generator, on lake steamers, and on the duplex compound air pump we found about 45 pounds of water, and in some cases it ran as high as 60 pounds per horse-power hour.

Mr. Mattsson:—I wish to present some additional data not given in the report as printed, but which will give us a check on the total amount of feedwater used.

First of all, the main engine—the steam was measured from the inlet period of the high pressure cylinder indicator cards and this volume of steam transferred into weight of water at the pressure indicated

	Pounds
We have per hour	32,900
Fan engine, 10 I. H. P. × 40 lbs. of water per hour	400
5 K. W. generator engine, 8 I. H. P. × 40 lbs. water per hour	320
Main feed pump, 10 I. H. P. × 100 lbs. water per hour	1,000
Steering engine, 10 I. H. P. × 60 lbs. water per hour	600
Fire pump (intermittent), 10 I. H. P. × 125 lbs. water per hour × 1/5	250
Incidentals	430
Water per hour total	35,900

The amount of water necessary for the feed pump was 37,758 pounds, thus the difference 37,758 − 35,900 = 1,858 pounds, or 1,858 × 100 ÷ 35,900 = 5.2 per cent, proving, as I have already stated in the discussion, that the total amount of water measured by the feed pump is only 5 per cent more than the amount of steam consumed by the main engine and the auxiliaries on the test. This 5 per cent is easily accounted for in the condensation in piping.

Regarding auxiliaries, we have very reliable data on the water consumption on the fan and generating engine as furnished by the manufacturer and found to be 40 pounds of water per indicated horse-power. The manufacturer of the feed pump also stated the water consumption as 100 pounds per indicated horse-power.

In conclusion, I would say this to the members of the Society—that when I particularly stated that it was not part of the paper, simply an addendum, it was my own discussion, and I wanted to bring it out for this reason—that we could possibly arrange to have a feed pump so well built we could use it in place of the meters. We know the meter is not reliable, and it is difficult always to get tanks aboard the ship. I thought we could make a start and see what we could do. The desire was to bring out discussion, and I think I have succeeded in that.

Mr. McFarland:—I think we all feel very much indebted to Mr. Mattsson for giving us this exceedingly valuable description of the vessel, and we all know that in the case of men who are seagoing people, engineers and others, that it is a matter of extreme difficulty to get information under ordinary conditions of running. As Mr. Mattsson says, you cannot put in measuring tanks and meters, and there are many other things you cannot do, and any honest effort to try to give this Society information of this character is something deserving of praise, and I hope he understands that we appreciate the fact that he has presented this paper to the Society.

Mr. Mattsson:—The feedwater was absolutely constant in the boiler and everything was measured. The coal was very carefully weighed. The ashes were carefully weighed, but the feedwater is doubtful.

The Chairman:—The thanks of the Society are due to the authors of any paper that promotes discussion. We need something, apparently, to wake us up. On behalf of the Society, I extend to Messrs. Mattsson and Durkin our appreciation of the paper presented.

Gentlemen, amongst the list of names of new members which the secretary read this morning appeared the name of Dr. K. Suyehiro. We will have the pleasure this afternoon of hearing him read the next paper on our program, No. 14, entitled "Devices for Comparing the Rotation of Shafts." This paper will be presented by Dr. Suyehiro, now a member of the Society.

Dr. Suyehiro presented the paper, and, in connection with its presentation, said:—

"I should like to add the fact that if the apparatus shown in Fig. 2, Plate 18, is used, two shafts may be connected within three or four minutes; if directly connected, and if indirectly connected, it takes about six or seven minutes."

DEVICES FOR COMPARING THE ROTATION OF SHAFTS.

By Dr. K. Suyehiro, Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

According to present practice, it is not uncommon that an engine shaft is required to be connected while running to another shaft in the same line by a clutch, the practice in war-ships driven by geared turbines and fitted with independent cruising turbines being a well-known example.

In such cases an indicating appliance, which is known under the name "synchroscope," is necessary for detecting the comparative speed of the two shafts, and, if possible, also their relative phase.

Sartori's stroboscope, epicyclic "jack-in-the-box" mechanism and other contrivances are used to this end, and have proved to work more or less successfully. But neither of them can show relative phase. As is well known, the former consists of a pair of circular plane discs with a common axis, each disc being pierced with oblique slits equal in number to the teeth of the dog clutch and cut in such a manner that the slits in one disc make a definite angle with those in the other. Therefore, if the circumference of a definite circle is cut on the front disc as a reference, the relative phase of the shafts is given by the position of the points of intersection of the slits relative to this circle, and the detection of the relative phase would not be absolutely impossible. Practically, however, when the speed of the shaft is high, it is a matter of the utmost difficulty, if not impossibility, to judge the flickering motion of the ray of light passing through the intersection of the slits, which changes its position from time to time.

In the apparatus which were devised by Mr. Tsuchiya of the Kawasaki Shipyard, Japan, and the author conjointly, the difficulty of observation was reduced to a minimum.

One apparatus, which was originally devised by the former, is shown in Plate 18. The underlying principle of this apparatus is the same as the author's torsion-meter,* namely, a part of a rotating body can be made visible by fitting a plane mirror parallel to the axis of revolution, in such a position that the mirror just bisects the distance of the part to be observed from the axis of revolution. As, by such an arrangement, the virtual image of the part to be observed is formed just on the line of the axis, the image remains practically at a standstill, in spite of the part to be observed actually revolving.

As shown in Plate 18, a hollow shaft s_1 and another shaft s_2 inside it are connected directly or indirectly to engine shafts, the revolution of which is to be com-

*"A torsion-meter, with visible scale," Transactions of Institution of Naval Architects, London, 1914.

pared. Wheels W_1 and W_2 are fitted to the end of the outer and inner shafts respectively. On the inside surface of the rim of the wheels small indicating marks m and m' are painted or engraved at equal intervals; in W_2 these intervals are equal to the pitch of the teeth of the dog clutch, by means of which the main shafts are connected and in W_1 twice this. Thus the relative angular speed, as well as the relative phase of the shafts, can be found by observing the relative motion of these marks if they are made visible while revolving. With this end in view, plane mirrors marked M are fitted on the wheel W_1 opposite to each mark just midway between the marks and the center of the shafts. For the reason described above, the marks on the wheel W_1 become visible by being brought virtually to the center of shaft; so that, if the position of these plane mirrors is well adjusted, the virtual images of all the marks are formed in one and the same spot on the axis of the shaft. As they appear one after another successively, these images of the marks seem like a fixed mark on the axis of the shaft.

The image of the marks m' on the wheel W_2 formed by the same mirrors behave in a different manner. As the angular velocities of the mirrors and the marks m' are different if not synchronized, the virtual images of m' are not fixed in position but move with the difference of the peripherical speeds of the wheels, this motion apparently occurring on a cylindrical surface passing through the center of the shaft. If the difference of the rotations of the shafts is moderate, this motion can be seen without difficulty. Looking at the center of the shafts in direction shown in Fig. 1, one can see a moving picture of the marks. Thus the relative motion of two shafts, as well as their phase relation, can be found without the least difficulty.

The drawback to this apparatus is that the use of glass mirrors cannot be avoided. Though the experience obtained with the author's torsion-meter tells him that a mirror, if carefully made damp-proof, keeps its brightness for a long time, yet the use of a brittle material such as glass should be avoided as far as possible in an apparatus having an important function. The break-down of a torsion-meter simply causes the non-measurement of the power, which is only a trifling matter, whereas failure in a synchroscope is far more serious.

In view of this, the author modified this apparatus, as shown in Plate 19. In this type the general construction is nearly the same as before, but here the use of mirrors is avoided; and the same effect is accomplished by introducing the principle of "Zoetrope," or rotating cinematograph. To this end, slits equal in number and interval to the indicating marks are cut on the cylindrical rim of the pan-shaped wheel W_1 in a manner shown in the diagram. It is well known that, with such a device, the inside surface of the cylindrical rim is visible while revolving if one peeps through the slits. When the speed difference of the two shafts is not high, the marks on the inner wheel W_2 can also be seen intermittently through the slits; owing to the persistence of vision the effect on the eye is the same as looking at continuous motion. Thus the relative motion of the two revolving shafts can be

found. However, as the speed difference becomes higher, the vision of the marks on the wheel W_2 appears confused and the observation becomes impossible.

To make this apparatus workable even under a high velocity difference, another pan-shaped wheel marked W_3 is added between W_1 and W_2. As shown in Fig. 1, Plate 19, this wheel works loose on the two shafts, and its hub is in friction contact with that of the wheel W_2 on its upper surface, while its lower surface rests on a ball seat on the boss of the wheel W_1. Wherefore the motion of this middle wheel W_3 would always follow the inner wheel W_2 if this were not prevented by pins.

As shown in Figs. 1 and 2, Plate 19, the pins are screwed into the bottom of the outer wheel W_1 and engage into slots Q cut in the bottom of the middle wheel; so that the relative motion of the wheels W_1 and W_3 is not perfectly free but allowed only to the extent limited by the length of the slots. The slots have such a length that the extreme relative turning corresponds to one-half of the interval of the indicating marks. Therefore, if the angular velocity of the inner wheel is larger than that of the outer one, the former pushes the middle wheel by the friction on the hub; and in the contrary case the latter drives the middle wheel with the pins. Thus the relative phase of the outer and the middle wheels changes by one-half of the interval of the indicating marks, according as the one shaft is quicker or slower than the other.

For indicating this change of phase, openings O are cut on the cylindrical rim of the outer wheel in a manner shown in the diagram, and the inside surface of the rim of the middle wheel is painted in two different colors, every alternate section which corresponds to one-half of the interval of the indicating marks having the same color. Therefore, in regulating the speed of one of the shafts, when one overruns the other, the color of the middle wheel, as seen through the openings O, changes from one sort to the other.

With this auxiliary arrangement, one can easily detect which shaft is running quicker than the other, whatever be the speed difference. Thus this color change tells qualitatively and the relative motion of the indicating marks quantitatively the relative motion of two shafts which are to be clutched while running.

Both the original and the modified patterns are used in many cases and work quite satisfactorily.

DISCUSSION.

The Chairman:—Is any one prepared to discuss this paper? If there is no discussion, I will on behalf of our Society extend to Dr. Suyehiro, from the Society in the Far East, our thanks for presenting this matter to us.

If there is nothing further to present to the Society at this time, a motion to adjourn will be in order. We will adjourn until ten o'clock to-morrow morning.

The meeting then adjourned.

THIRD SESSION.

FRIDAY MORNING, NOVEMBER 16, 1917.

President Taylor called the meeting to order at 10.30 a.m.

THE PRESIDENT:—The first paper presented this morning is No. 5, entitled, "Cargo Ship Lines of Simple Form," by Naval Constructor Wm. McEntee, Member. This paper was postponed from yesterday, and will now be taken up.

Naval Constructor McEntee presented the paper.

CARGO SHIP LINES OF SIMPLE FORM.

By Naval Constructor William McEntee, U S. N., Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

The recent wide discussion and general interest in the possibilities of standard cargo ships to be built in large numbers from standard plans have naturally brought into prominence the matter of simplifying the form of ships.

The tendency in ship construction for a long period has been in the direction of simplification. If, for example, the sailing vessels which formed the Spanish Armada, with their high poops and forecastles and overhanging galleries, are compared with the present-day ship, the effect of this tendency is shown very clearly. A part of the change has, no doubt, been due to the introduction of steam power and the increase in size of ships made possible by their construction of iron and steel, but even before the era of steam-propelled iron and steel ships the tendency toward simplification was having a decided effect.

In this gradual change there has been a greater variation in the form of that part of the ship above the water line. This is possibly due to the fact that there was more latitude in the upper works for the expression of individual ideas, or for artistic embellishment, than there was with the under-water body.

In order to make any reasonable progress through water the under-water form had to be of some reasonably good shape, and the practical limits of form variation were more restricted. An examination of the lines of one of the large boats, or small ships, used by the Norsemen nearly one thousand years ago shows that for their purpose the shape of the under-water body was almost equal to the best we have to-day.

In general, the simplification of form requires the use of plain surfaces at right angles instead of curved surfaces wherever possible. Where curvature is unavoidable, the simplest of curves, the circle, should be used. All curvature should be in one direction only, that is, surfaces of double curvature should be avoided so far as possible.

These considerations lead, in the forming of a ship, to the adoption of a midship section formed by two vertical lines and a horizontal line at the bottom, the corners or bilges being rounded off by circles of suitable radius. The sides and bottom of the ship will be flat surfaces carrying the full midship section well forward and aft, making what is known as the parallel middle body extend as far as possible without excessive increase in resistance. Forward, where it is necessary to fine the lines to form an entrance, it can be done by gradually decreasing the width of the ship, keeping the bottom flat and the sides vertical, the bilge being

formed by a quarter circle of constant radius equal to that used for the middle part of the vessel.

Aft, the possibilities of simplification are limited by the necessity for providing space for the propellers. Two different methods of simplifying the after body are shown in Model 1,997 and Model 2,056, Figs. 1 and 2, Plates 20 and 21. The general result in these forms is to make the water line somewhat wider and place the displacement higher up. This arrangement seems favorable from both the resistance and the propulsion standpoints, but may have disadvantages as regard sea-going qualities.

In the present investigation an attempt has been made to show how the power required for propulsion is affected by simplification of the lines of three different types of cargo vessels.

Models 1,978 and 1,997, lines of which are shown on Fig. 1, are models of a 160-foot oil fuel barge of 830 and 850 tons, respectively. Through a slight error in making Model 1,997, the cylindrical or prismatic coefficient and displacement are somewhat larger than for the model with which it is compared, that is, No. 1,978 of conventional form. The effect ve horse-power curves for the estimated power are shown in Fig. 4, Plate 23. It will be seen that the curves are very nearly the same, the simplified form requiring about 35 effective horse-power at 6 knots as compared with 34 for the conventional form.

Models 2,023 and 2,056, lines of which are shown in Fig. 2, Plate 21, are of a 400-foot, 10.5-knot cargo ship of the usual single-screw type. At 10.5 knots it will be seen from the power curves, shown in Fig. 5, Plate 24, that the simplified form requires something less than 2 per cent greater effective horse-power than for the conventional form. As Model 2,023 gave results which were considered to be good for this type of vessel, it follows that the simplified form, Model 2,056, would require appreciably less power than many cargo ships of conventional form in this general class now built and building.

In Fig. 3, Plate 22, are shown the lines of the U. S. collier Neptune, and of a 500-foot cargo vessel of simplified lines and somewhat greater displacement. The effective horse-power curves for these two models are given in Fig. 6, Plate 25. On this plate, also, is shown the estimated effective horse-power curve for a 500-foot ship of conventional form having the same displacement, 20,000 tons, and the same cylindrical or prismatic coefficient, .74. This latter curve is estimated from tests of one of a series of models of conventional form. The simplified form requires a little more power than the latter for speeds up to 13 knots. From that up to a speed of about 17 knots, the simplified form is the better, the advantage at a speed of 15 knots being in the neighborhood of 7 per cent. On the same sheet it will be seen that the Neptune, which is of the conventional form, but 520 feet in length and of somewhat less displacement, that is, 19,340 tons, requires in general more power than the simplified lines.

The main dimensions of the models, or rather of the ships represented by them, are given in Table I.

In general, it appears to be safe to conclude that cargo vessels can be built of simplified lines which will give practically as good results from the resistance standpoint as those built from the present conventional lines. If propulsive efficiency is also taken into account, it is believed that the simplified form will have, at least in certain cases, advantages over the present type.

TABLE I.—*Dimensions.*

Model No.	Type	Length	Beam	Draught	Displacement	Speed	E. H. P.	Long. coef.	Midship section coef.	Parallel middle body.
		Feet	*Feet*	*Feet*	*Tons*	*Knots*				*Per cent*
1978	Oil fuel barge, conventional form	160	25	9.25	830	6	34.4	.80	.98	30
1997	Oil fuel barge, simplified lines	160	25	9.25	850	6	35.6	.82	.98	40
2023	400-foot freighter, conventional form ..	400	57.3	26	13,137	10.5	1080	.788	.987	33.4
2056	400-foot freighter, simplified lines	400	57.3	26	13,137	10.5	1120	.788	.987	33.4
*Series	500-foot cargo vessel, conventional form	500	73.6	26.77	20,000	14	3440	.74	.96	30
2045	500-foot cargo vessel, simplified lines ..	500	72.5	26.375	20,000	14	3290	.74	.989	30
1121	U. S. collier Neptune	520	65	27.5	19,340	14	3460	.738	.983	25

*Estimated from Experimental Model Basin's Parallel Middle Body Series (No. 26).

DISCUSSION.

THE PRESIDENT:—Gentlemen, this paper on "Cargo Ship Lines of Simple Form" is now before you for discussion.

PROFESSOR HERBERT C. SADLER, *Member of Council:*—Mr. President and gentlemen, the shipbuilding and ship designing profession is apt to be somewhat conservative, and perhaps rightly so, in connection with the shape of ships, particularly when we take into account all factors involved; and it seems to take somewhat of a cataclysm, such as is occurring at the present time, to make us change some of our preconceived ideas on ships' form.

Naval Constructor McEntee has shown us three different types where the form can be considerably simplified and practically the same results, if not better results, obtained as compared with the ordinary form. He has laid down some essentials of simplification. The one criticism I have to make is that perhaps he has not gone far enough.

Recently in our tank at the University of Michigan we have been conducting some experiments on forms that have no curvature except in one direction; that is, we have done away with the circular bilge and have used perfectly straight lines. Perhaps I might illustrate the form on the blackboard. (See Fig. 1, Plate 26.) The after body is of the same general form as that shown in the fore body. The lines are all perfectly straight to the sharp corner. To try the effect of a simple bilge, the corner of the model is then cut off in that way

(indicating) making a flat surface in that form (indicating). The interesting thing we found with some of these models was that we could actually get a form with less resistance than that of some of the vessels actually building at the present time. We have no double curvature at all in any place, as you see.

We have tried this out with one or two full types and are at the present time working on some fine types, and recently we made some experiments with boats of 0.6 to 0.7 coefficient.

We have made so far three models in each case, one of the recognized shipshape form, one with the diagonal line running from the corner of the bilge to the water-line, and another one with the slope of this line changed, to see if there is much effect in changing the slope of the flat part of the bilge.

All these models were exactly the same size, same curve of sectional areas, same coefficients, and same water-line. We could not detect any difference between the shipshape form and this simplified form, with the corners cut off, until we got to speeds beyond which that particular form would be normally driven, and then the shipshape form showed up better, but for all practical purposes this simplified form could be driven practically as easily as the shipshape form.

In regard to the sharp corner, we have found all the difference that makes, as compared with the corner cut off, is from about 2 to 5 per cent in the fastest form and a little more than that in the fuller forms, so that if we would only be brave enough to build vessels of this type you see that the constructional features would be considerably simplified.

In Mr. McEntee's forms you notice we still have the double curvature at the bilge when we get towards the ends of the ship, and therefore have dished plates.

The question in each case to determine is the right slope for this flat part of the vessel; if it runs across stream lines, that means, of course, the resistance is increased. I think also, as far as seagoing qualities are concerned, that the simple form would be as good as the shipshape form, and certainly so for pounding forward, as the forward lines are sharper and easier. I do not think the structure would be so badly affected as in the flatter form of the ordinary ship. The corners would probably act somewhat in the nature of bilge keels, and there would probably be no necessity for placing the bilge keels on vessels of this type.

I am sorry the experiments I have referred to are not completed, but will be glad to submit them later on.

Mr. Laurence H. McMurtrie, *Member*:—Can you not give us the essential features—show us how you construct it and make that section? The under frame would be upset.

Professor Sadler:—The double bottom ships would be of that character (indicating on diagram on blackboard), the ordinary frame running down here practically to the corner, and the margin plate running at right angles to the bilge. (See Fig. 3, Plate 26.)

Mr. McMurtrie:—Then the plate would come down to the knuckle in each case?

Professor Sadler:—Yes.

Mr. McMurtrie:—How would you make that tight?

Professor Sadler:—We would stop the plates at these particular points (indicating) and then put a small flange plate over the joint.

MR. MCMURTRIE:—That would probably be simpler. Do you think that would be good construction—that it would satisfy the insurance authorities?

PROFESSOR SADLER:—As a matter of fact, this form of construction has been passed by Lloyd's and the American Bureau.

MR. WILLIAM N. HOWELL, *Member:*—Have you made any experiments on models without any rise fore and aft, perfectly flat-bottom boats, like those ninety-day gunboats during the Civil War?

PROFESSOR SADLER:—In the finer lined models, we gave them a rise of floor more or less to conform somewhat to the present practice, instead of the very fullest midship section possible. In the full models we practically gave them no rise.

THE CHAIRMAN:—Have not some contracts been given by the Emergency Fleet Corporation for vessels of this character?

PROFESSOR SADLER:—I understand so.

THE CHAIRMAN:—Is there any further discussion? If not, I will ask Naval Constructor McEntee to close the discussion.

NAVAL CONSTRUCTOR MCENTEE:—In the course of experiments at the Model Basin at Washington, we have tried some models of that general type proposed by a man who is building a concrete ship, models of the general type shown by Professor Sadler. The model did not do particularly well, and I imagine the trouble was not so much due to the lines as to the selection of coefficient of displacement or curve of sectional area.

In general, I should say that this type, so far as the fore body is concerned, would have some disadvantages as compared to the type described in my paper. For one thing, this form of section would put the displacement forward, high up at the water-line, and there would be little displacement at the forefoot. I think it is pretty well established that for all types of ships the U-form of frame forward is desirable. Personally I think also that the finer water-line that comes with the U-section forward has considerable advantages in a seaway, and I hope before long to make some experiments in waves, at the Model Basin at Washington, to see what effect fine entrance has on seagoing qualities as regards resistance in waves.

With regard to the form of ship described by Professor Sadler, which does away with double curvature at the bilge, I think in that portion of the ship where the frame elements are straight lines, but not parallel to each other, there is a conical surface of double curvature. In laying off the plating the frame lines on the plates would not come perpendicular to the plate edge, but would come at varying angles, depending on the location. The form which has the frame elements parallel to each other would bring all of the frame lines and lines of the rivet holes at right angles to the length of the plate. For convenience in laying off and also if the plates are punched in an automatic spacing punch, I think the form of model I have used will have an advantage.

MR. MCMURTRIE:—Please tell us, Mr. McEntee, what you think the effect would be when a ship having the bow arranged vertically, as recommended, plunged into a heavy sea.

It is my opinion that water would come on board in great masses, making her a very "dirty" or wet ship in a seaway.

I have been across the Atlantic on board a ship without the "flaring" bow, and know what loads of water came on deck when she was bucking into a heavy sea, and have been on other ships having considerable "flare" foreward, which made them "dry" and comfortable vessels in very stormy weather.

Naval Constructor McEntee:—That is more or less of a moot question. Nearly every naval architect has his own views on it, some thinking that the flared bow and full water-line is the best, and others that the hollow water-line is the best. That point was discussed by Mr. Froude in a paper ten or fifteen years ago. The fact that the water is thrown away from the bow indicates to my mind that power must be used to accomplish that purpose.

In my short sea service as a midshipman I was on a gunboat that had the old clipper type of flaring bow, and every time she dove into a head sea she would come up with a shudder all over, indicating that she had met with a very high resistance. I think that would indicate that the hollow water-line, with perfectly straight sections vertically, would have less resistance than the flared bow, but whether more water would come aboard, and thus counteract that, I am not prepared to say.

Professor Sadler:—We have tried some modification of this development—we have them under way just now, which will perhaps overcome some objections which have been raised, that the bottom line need not necessarily be kept parallel with the top one, and that if there is any feeling that the end sections have not enough displacement, the form would be easily modified to give any displacement at the bottom of the section you wish and still retain the flat feature of the bilge plate (Fig. 2, Plate 26). I think that the flat feature is a good deal more important than the fact that some plates have a slight twist upon them. You can put these plates in rolls and roll them diagonally; they will take a natural twist and lie flat on the bottom. They are very easy to make. We have tried it on the model.

There is another point in which I perhaps do not quite agree with Naval Constructor McEntee, and that is in the shape of the bow section for all types of ships. He made the statement that the U-shape section was the best for all types. My experience has been that with full-ended ships, running about 0.8 coefficient, we have obtained considerably better results by easing up the bilge at the forward end and rather filling out the water-line—doing away with the heavy bilge low down—and that seems to be perfectly reasonable and according to what you would expect from the flow lines of the vessel.

When the full-ended vessel is being driven up to about her maximum speed, her ends are in somewhat the same condition as the fine-ended vessel running at high speed, and in this case we know that the question of letting the water under the whole body of the vessel easily is a very important one, and consequently in this full-ended vessel, where there is a tendency for most of the water to dive underneath, if you can ease up this full line (indicating) down at the bottom, you will get a form that is generally more easily driven. In fact, the logic of the thing is the same in both the fine and the full-ended ship.

The President:—Does Naval Constructor McEntee wish to respond?

NAVAL CONSTRUCTOR MCENTEE:—I think the case Professor Sadler has described might be put in another form by saying that the radius at the turn of the bilge forward should be ample.

I think that the reason for my statement as to the advantage in all types of ships in having the displacement low may be explained in a somewhat theoretical way by saying for forms which run wholly submerged, like submarines, at a given displacement the blunt form is decidedly the best. For forms that run near the surface, the sharp form, so far as wave-making lines are concerned, is the best.

In the ordinary ship, going from the forefoot to the water-line, there is a change really from a submarine to a surface ship. The acceleration which the water at the surface ahead of the ship receives from the displacement low down is much more gently imparted, and therefore causes the water to flow away from the line of the ship with less wave-making than if the impulse is received from displacement which is near the water-line. I think, though in certain models the water-line displacement forward may seem to have an advantage, yet if the matter is thoroughly investigated, and, as I say, the entrance made easier by making the radius at the bottom larger so as to permit the water to flow under the bottom, that the results with the U-shape section would be equally as good.

THE PRESIDENT:—The thanks of the Society are due to Naval Constructor McEntee for this very important addition to our Transactions, and I trust that in the experiments that Professor Sadler and Mr. McEntee are to make that they will give us the advantage of having the results as a continuation of this discussion.

I also suggest that they add to the present discussion sketches that will cover the ground covered by the sketches which they have put on the blackboard.

The next paper is No. 8, entitled "Labor and Patriotism," by Assistant Naval Constructor A. W. Carmichael, Member.

REMARKS ON LABOR AND PATRIOTISM.

Assistant Naval Constructor A. W. Carmichael, *Member:*—Mr. President and members of the Society, I had prepared a paper on the subject that has been announced by the President, and in accordance with the regulations for the government of the United States Navy I submitted this paper to the Navy Department for approval. I regret to say that I have not obtained this approval.

I would just like to read to you a few paragraphs from a newspaper clipping, not from my paper. One of the paragraphs I refer to is taken from the address of President Wilson at the Buffalo meeting of the American Federation of Labor, and is as follows:—

"If we are true friends of freedom—our own or anybody else's—we will see that the power of this country and the productivity of this country is raised to its absolute maximum, and that absolutely nobody is allowed to stand in the way of it."

I am sure that every member of this Society, and every loyal and patriotic citizen, stands fully behind the President when he says this. We must have the maximum of productivity. Productivity represents the natural resources of the country to which labor is applied. Capital alone is helpless. We must have the assistance of labor.

To give a simple illustration, let us take any trade employed in the war industries. For example, let us take the trade of a riveter. A riveter who can drive one hundred rivets a day and who drives only thirty of them a day; a riveter who is physically able to work six days a week and only works three days a week; a riveter who demands and insists upon a wage that is in excess of his productivity; a riveter who rivets the structure of a palatial hotel when he could be riveting the structure of a ship, is standing in the way of that productivity.

We have been told that the American Federation of Labor is educating workmen in this country to a proper realization of their patriotic duty. Will the American Federation of Labor tell us how long it is going to take to educate them up to this? Why have they only started to educate labor to a proper realization of its patriotic duty eight months after we have entered the war?

I now want to read to you, gentlemen, a few paragraphs from a book by one of the greatest of Americans, Mr. Hudson Maxim, entitled "Defenseless America." He says:—

"Come, my young lady reader, let us, in imagination, stand together on the firing line. Those regiments lining up are from New York, New Jersey, Connecticut, and Massachusetts. They are forming for a charge. It is the only way. Those shells bursting among them with such deadly effect are shrapnel from the quick-firing guns of the enemy placed just over the crest of yonder distant ridge; and those huge plunging projectiles, which throw up great inverted cones of earth, with fragments of men, are from the enemy's big howitzers, located under cover of the wood that fringes the horizon.

"If we only had the necessary quick-firing field guns and shrapnel ammunition, and the necessary field howitzers, we might dislodge or silence those deadly batteries of the enemy. At any rate, we should be able to engage them sufficiently and cover the charge of our troops. We should also be able to storm that line of trenches, to the discomfiture of the

enemy hidden there in vast numbers, and thus be prepared for the onset of our men. But we have neither the guns nor the ammunition.

"See!—the order is given. Onward they go. Watch them, the brave fellows! Why does the front line lie down so suddenly, with a few left standing? My friend, they are not lying down; they are dead. But they are not all killed; a large number of them are wounded. They are torn in every inconceivable, horrible manner of mutilation. And look! The other line goes down, too; some lying still, others writhing on the ground. One of those poor devils, with hands clenched in the grass and gnawing the earth, is your brother!

"See!—a huge howitzer shell explodes right among them. The young man whom you were to marry on his return from the war was standing on the verge of the crater when the explosion came, and he is now lying there, with both eyes blown out by the awful blast and hanging on his cheeks. There are visions of you in the blasted eyes, and there are thoughts of you in the dazed brain, and his dying breath is a whisper of your name."

Gentlemen, how long must we wait for labor to swing into line?

In closing I want to read a telegram sent the other day by the National Founders' Association to the President of the United States, approved at the Twenty-first Annual Convention of that association held in New York City. It is as follows:—

"The National Founders' Association, composed of nearly six hundred manufacturers operating iron and steel foundries, and employing scores of thousands of workmen, in Annual Convention assembled, unanimously pledges to you and our country the unswerving loyalty of its members and the resource of its industrial plants.

"To gain that measure of efficiency requisite for the proper equipment of our Army and Navy, we stand squarely on the platform that the processes of labor shall not be interfered with, and that employees throughout the various industries of the nation may be quickly brought to a realization of the fact that autocracy of labor is fully as disturbing to the welfare of mankind as is the autocracy of government.

"With full and complete support of their employees, the manufacturers of our country will back the boys in the trenches to the limit without thought of emolument, but they will be powerless unless the present autocratic demands of labor for purely selfish advantage are dissipated.

"We are unqualifiedly in accord with the declaration of the Council of National Defense that industrial and labor conditions as existing prior to the war should continue for the duration of the war. Any action to the contrary, whether of industry shirking its duty or labor interposing restrictions of production and attempting to change existing conditions, should be regarded as treason and punished as such.

"We realize that there must be absolutely loyal cooperation between employer and employee until this war is won; that patriotism must be unsullied and uninfluenced by personal gains and selfish consideration; that the mutual pledges of representatives of the workingmen and directors of industries must be kept inviolate until a righteous peace is established on the earth."

The President:—Gentlemen, this is not a formal paper; but the subject is before you for consideration. If any of you care to add to the discussion, we will be very glad to hear from you. The questions which have been put up by Mr. Carmichael are of very great importance. They have troubled me a great deal in my consideration of what I should say before this Society. I have felt that those in authority knew more about the subject than I,

and I hesitated to say anything whatever on it. So in the presidential address yesterday morning there was but a very brief reference to this subject which, however, if the address is read carefully, will indicate the attitude of my own mind. It is quite possible that I may change my intention—I thought I would not venture to discuss this question in public, so long as the President of the United States and those associated with him are endeavoring to determine the matters. If, before the day is over, I should step over the line of demarcation that I have made for myself, it will be solely because I feel that it is a question the patriots of this country have got to study. I should be very glad, indeed, to hear from any other gentleman in the room on this subject. Some of us are in uniforms and we hesitate to say all we feel, but there are still free American citizens in this room who are not trammeled by their uniforms. We should be very glad to hear from them.

I want to say just another word in reference to the paper that was written by Mr. Carmichael. I read it carefully when it was first brought to my attention, and while I had intended to say something in the presidential address along similar lines, what he wrote was so much better than what I would have said, I made up my mind to leave that question to his paper solely. I want to say that in justice to Mr. Carmichael. If any other gentleman cares to say anything, we will be glad to hear from him. If not, we will pass to another paper.

Professor Herbert C. Sadler, *Member*:—I feel that this is a question in which, as a Society, we are particularly interested at the present time. I fortunately, or unfortunately, am not an employer of labor, but this Society, particularly at the present crisis, is vitally interested in the production of ships. It has occurred to me, while the president was talking, whether it would not be advisable for this Society to go on record in some way so as to give the authorities in this country our ideas on this subject, whether these ideas would not be helpful to them at the present time, as representing the consensus of opinion of the one society that is most vitally interested in the big problem that this country is tackling at the present time.

The President:—If there is no further discussion I will extend the thanks of the Society to Mr. Carmichael for his intention to produce a most interesting paper and for his remarks.

The next paper to be considered is No. 9 entitled, "Application of Electricity to Various Auxiliaries on Shipboard," by Mr. H. L. Hibbard, Member.

Mr. Hibbard presented the paper.

APPLICATION OF ELECTRICITY TO VARIOUS AUXILIARIES ON SHIPBOARD.

By H. L. Hibbard, Esq., Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

For the past several years the attention of the Society has been invited at intervals to the application of electricity in various forms to vessels in both the naval and merchant service. Mr. Donnelly some years ago described his proposed electrically operated ship Electra. Mr. Emmett has presented several papers on electrical propulsion, particularly with reference to its application to naval vessels. Developments have recently been such, however, that the time seems opportune for the consideration of the general application of electricity to merchant vessels, not only as to the possible advantages gained in their propulsion, but particularly also to the operation of their auxiliaries, in the light of results already attained and installations contracted for.

The marine engineer and the seafaring man in general are naturally conservative in the adoption of new and untried apparatus. The time is rapidly approaching, however, if not already here, when the results obtained will justify the construction generally of vessels electrically equipped in all or many of their power applications. It is here interesting to note that in the use of electricity the American Navy has not only been far in advance of the merchant marine, but, we believe, has led all navies of the world. Europe, however, seems to have led this country in the trial of electrical apparatus for auxiliaries on merchant vessels.

Two or three years ago, the Christian X created much interest on its first voyage here with its oil propelling engines and electrically operated auxiliaries. Similarly, last winter, the Chile, constructed by Baumeister and Wayne, was visited while in New York harbor by many marine and electrical engineers. This vessel, of 13,400 tons displacement and provided with oil engines of a total horsepower of over 3,000, was equipped throughout with electrically operated auxiliaries, both for engine-room and deck machinery. Three Diesel engine-driven, 60-kilowatt generators furnished direct current to the auxiliaries at 220 volts. We understand, however, that one of these generating sets was sufficient to supply auxiliary power while at sea, and two were used while handling cargo in port. At least one generating set was, therefore, always available as spare.

In the engine-room equipment were included motor-operated ventilation fans, motor-driven centrifugal, circulating water pumps, bilge and sanitary pumps, ballast pumps, engine-turning motor, motor for operating tools in repair shop, etc.

In the deck equipment, electrically operated steering gear, deck winches and anchor windlass were provided.

As far as we have been able to ascertain, the result of the operation of these equipments has been in every way satisfactory on this vessel, and an interesting article as to the general performance of the vessel was contained in the February issue of *Motorship*. In a visit to this vessel the writer noted with particular interest, in the limited time available, the construction and distribution of the electrical equipment, and although it was perhaps somewhat clumsy in design, measured by our standards, it was certainly ruggedly constructed and, as far as we were able to learn from the engineers in charge, it appeared that they were well pleased with its performance and had encountered no particular difficulties.

In this connection we would draw attention to the influence which the growing use of oil-operated engines has on the adoption of electricity for ship auxiliaries. An article appearing in the March issue of *Motorship* by Mr. G. E. Smith, chief engineer of the American Engineering Company, reviews this situation and makes the significant remark that "the writer is firmly of the opinion that within a very short time all auxiliaries on motor ships will be electrically driven."

The Wm. Cramp & Sons Ship and Engine Building Company, holding patent rights under Baumeister and Wayne for oil-engine construction, decided on their own initiative, the first of this year, to construct a very similar vessel to the Chile, and we had the pleasure of figuring on the electrical equipment for its auxiliaries, which were generally similar in number and horse-power to the Chile's but, we believe, would have been improved in certain details of construction. Unfortunately, however, the Government, having commandeered this ship with all others, was unwilling to allow the Cramp Company to install the oil engines and electrical auxiliaries contemplated; we presume in view of the fear of being unable to obtain such apparatus within the time desired.

At last year's meeting of the Society, a paper by Mr. Frear was presented, covering a description and results obtained from the oil tanker La Brea, which was apparently the first instance of electrically operated cargo pumps on a tank ship, and, as indicated in Mr. Frear's paper, the results were very gratifying, particularly when compared to her sister ship, the Los Angeles, equipped with reciprocating engines and steam pumps in comparison to the geared steam turbine and electrical pumps on the La Brea.

Among the most striking examples of the use of electricity on merchant vessels are the boats being constructed and projected by the Pennsylvania Shipbuilding Company at Gloucester City, New Jersey. This company has under construction six tank steamers of about 7,500 tons displacement, one of which is nearly completed and another will take the water shortly, which will be propelled by geared steam turbines and their auxiliaries operated by electricity throughout. The electrical equipment on each of these vessels will consist of the following:—

2 100-kilowatt, 3 phase, 60 cycle, 220 volt, steam turbo generating sets.
1 anchor windlass, 25-horse-power slip-ring type motor.

1 forced draft fan, 25-horse-power slip-ring type motor.
1 steering gear equipment, 15-horse-power squirrel cage type motor.
2 cargo oil pumps, 80-horse-power squirrel cage motors, 3 speed, pole changing.
2 deck winches, 15-horse-power, squirrel cage type motors.
1 warping winch, 15-horse-power squirrel cage type motor.
1 oil transfer pump, 5-horse-power squirrel cage type motor.
1 forward bilge pump, 5-horse-power squirrel cage type motor.
1 bilge pump for pump room, 5-horse-power squirrel cage type motor.
1 circulating water pump, 5-horse-power squirrel cage type motor.
1 workshop motor, 5-horse-power squirrel cage type.
1 refrigerating plant, 5-horse-power squirrel cage type motor.
1 oil tank ventilation blower, 5-horse-power squirrel cage type motor.
1 fresh water pump, 5-horse-power squirrel cage type motor.

In addition to the above tankers, two cargo vessels of 12,000 tons displacement will soon be laid down and which will have an equipment of auxiliary motors similar to the above tank vessels with the exception of the deck winches, which will consist of three of 25 horse-power and eight of 15 horse-power. It is further contemplated that these two cargo vessels will be electrically propelled and operated by two turbo generating sets, each set furnishing current to a 1,500-horse-power motor, the two motors being geared to the single propeller shaft.

In addition to these vessels, this company contemplates the construction also of six cargo boats propelled by geared steam turbines and with electrical auxiliaries similar to the above.

For the above vessels open-type alternating current motors will be provided throughout and watertight enclosing cases furnished for the deck motors, with the particular view to protecting them from exposure to moisture; but the cases can be removed, if desired, when the vessels are in port, to give the motors ample ventilation.

The majority of the motors will be operated from a common switchboard in the generator room, and in most cases no means is provided for starting or stopping the motors at the auxiliary. A particular exception is the case of the anchor windlass having its controller near the motor on deck.

It will be noted that alternating current has been employed throughout on the above vessels, and those advocating the same point to the necessity, in the case of the tank vessels, of using the alternating current squirrel cage type motor with its freedom from moving contacts in places exposed to the possible presence of oil vapor. With the same object, the controlling devices, as described above, are all centralized in the generator room. On these vessels also an interesting form of deck winch is used for the first time, employing a constant running motor and a set of planetary gears, so arranged that, by the operation of a lever and two brake bands, the load can be stopped or the speed of the winch varied while the motor continues to operate at constant speed.

In contrast to the alternating current used on the above vessels, the Texas Oil Company is soon to construct a tank vessel of approximately 6,000 tons displacement, propelled by fuel oil engines and provided with direct-current, 230-volt motors on its auxiliaries. The principal auxiliary equipments on this vessel will be as follows, although a few additional will probably be eventually supplied:—

6 30-horse-power variable speed cargo pump motors, enclosed type, variable speed.
1 20-horse-power fire-room bilge pump motor, enclosed type, constant speed.
4 5-horse-power constant speed, enclosed type motors for operating auxiliary pumps.
2 refrigerating machines, 3-horse-power enclosed type motors, variable speed.
1 10-horse-power steering gear motor, open type, constant speed.
2 cargo deck winches, 20-horse-power enclosed type, compound wound.
1 20-horse-power capstan, open type compound wound.
1 25-horse-power windlass, enclosed type, compound wound.

The six cargo pump motors and the bilge pump motor, all, we understand, located in the same compartment, will be operated from controllers on a common switchboard in the generator room, similar to the arrangement for the Pennsylvania Shipbuilding Company's tankers. In addition, however, watertight push-button stations will be located adjacent to the motors which will stop the pumps when desired, to be again started from the generator room. The cargo pump motors and the motors exposed on deck will be probably provided with enclosing cases, furnished with forced ventilation, or this forced ventilation carried directly into the enclosed motor frames.

While it is not here the intention to discuss in detail the relative merits of various kinds of motors, it may be mentioned that in comparing the direct-current with the alternating-current equipments mentioned above, a saving in wiring, flexibility of speed control, and improved speed and torque characteristics for the deck auxiliaries are on the side of the direct-current equipments. The alternating-current motor, as pointed out above, has the advantage of freedom from moving contacts and the reduction, in consequence, to a minimum of the possibility of sparks in places where inflammable gases might be encountered, as in the case of the tank steamers. This, however, applies particularly to the constant speed, squirrel-cage type of alternating-current motor, the slip-ring type of motor which is required for some applications being provided with moving contacts.

In connection with the electric propulsion of ships, it is interesting to note that, in addition to the very considerable number of electrically propelled ships now being constructed for the Navy, this mode of propulsion is receiving considerable attention in its application to merchant vessels. In addition to the two cargo vessels at the Pennsylvania Shipbuilding Company's plant, which it is expected to propel electrically, we are familiar with electrical installations on four oil barges under

construction at New Orleans by the Petroleum Transport Company. These boats are twin screw, each propeller being driven by a 300-horse-power, 480-volt, 3-phase, 60-cycle motor, the two motors being operated by one turbo generating set of similar voltage and frequency. These motors are operated by automatic contactor controllers from a common master station, two control levers giving straight-line motion similar to the valve levers of the usual reciprocating engine installation.

While the geared steam turbine has shown some excellent results and the use of the heavy oil engine for propulsion purposes will probably be more extended—and possibly Mr. Emmett has, under these later developments, modified his views somewhat regarding electric propulsion—it will be seen from the above that this feature of electrical application on shipboard is receiving continued attention and its further application is to be predicted.

A combination which may receive a good deal of consideration in the future in this connection, especially for equipments of average size, is the operation of one or two generating sets by oil engines instead of steam turbines, the generators to operate the propelling motors as at present. Such an arrangement provides the advantages of the use of fuel oil, at the same time retaining the flexibility of the electrical drive and permitting oil engines to be furnished without reversing features.

We have thus seen some of the progress which has been made in this application of power in the merchant field, and we feel certain that its application by this time would have been considerably more extended had not the war conditions necessitated, at least in the opinion of the government officials, foregoing consideration of electrical apparatus in favor of steam in order to produce a merchant fleet in the shortest possible time. The progress made, however, is noteworthy, especially in view of the opposition which has been encountered to the use of electricity until recently from many of the steamship companies, shipyards and manufacturers of steam apparatus. The writer recalls with interest some years ago one of the head officials of a large shipyard, manufacturing steam auxiliaries as well, advising frankly that he would use every effort to defeat the installation of electric auxiliaries on a large freight vessel which was then under contemplation. We are pleased to believe, however, that such attitudes are changing rapidly.

We feel it is unnecessary at this time to refer in detail to the wide application of electricity in the American Navy or to the very satisfactory results which have been obtained from practically all of the apparatus so driven. This at least, in a general way, is thoroughly known by members of the Society. It has been stated frequently in the past, however, that results could not be expected on merchant vessels similar to those obtained in the Navy, owing to the much higher class of operators on naval vessels, and that the average freight vessel did not carry men in any way familiar with electrical apparatus. The remark has often been heard also in connection with a contemplated vessel or one under reconstruction, that the general use of electric power would require a generating plant of possibly

100 kilowatts, whereas the generators which we have or had expected to purchase are of 10 or 15 kilowatts.

The above situation is mentioned in the hope that it may be possible in the near future to create a new atmosphere of thought in the minds of the steamship lines, naval architects, etc., as it is obviously essential that a ship using electricity to any extent should have a power plant of equivalent size, and also that such vessels should be provided with at least one operating engineer, who is sufficiently versed in electrical matters to be able to make slight adjustments and repairs in the same way that steam engineers can readily repair broken parts of steam machinery and consider the same merely as a part of their routine duty.

In addition to the advantages which have been considered and resulted from electrical installations on naval vessels, numerous specific advantages are apparent in connection with such installations in the merchant marine, including frequently a saving in space and weight in the installation of the auxiliaries themselves, a very much higher efficiency of operation, and consequent saving in total fuel consumption, the elimination of long and objectional lines of steam piping, which on certain classes of cargo vessels are nearly always installed above deck and result in continual steam condensation; also, on certain of the auxiliaries, particularly those requiring varying speed and load conditions, the electric motor offers some distinct advantages over the use of the steam engine.

Time has not been available for the writer to prepare detailed data and illustrations to accompany this outline of the present situation and we have felt in fact that, owing to the considerable number of installations now being effected, more interesting and valuable data could be submitted for the Society's information at one of its meetings in the near future, after trials of a number of the vessels now under construction have been made. Should it therefore be the wish of the Society, the writer will endeavor to present such additional information and detailed data at a future meeting.

DISCUSSION.

The President:—Gentlemen, this paper, entitled "Application of Electricity to Various Auxiliaries on Shipboard," is now before you for discussion.

Mr. M. W. Day, *Associate*:—Mr. Hibbard's interesting paper, I hope, may be considered as the second in a series of papers on electrical auxiliaries for merchant ships beginning with Mr. Hugo P. Frear's paper on "Electric Pumping Equipment and Notes of Interest on Union Oil Company of California's Tank Steamer La Brea," and I second Mr. Hibbard's suggestion that at a later meeting, possibly next year, this subject may be gone into more thoroughly.

Many of the equipments which Mr. Hibbard mentioned are under construction, the vessels have not yet been completely equipped, and it is therefore expected that in another year more valuable data can be submitted in comparing the relative merits of steam and electric drive.

Although the use of electric auxiliaries is old and successful in the Navy, they have not been very largely applied, so far, in the merchant marine, and yet it is not altogether new in the merchant marine, because about sixteen years ago electric equipments were furnished for the Minnesota and Dakota and those equipments have been operating, I believe, on one vessel about fifteen years and have shown their justification in satisfactory operation. The other vessel was wrecked several years ago.

Quite recently a large number of direct-current electric winch equipments have been provided for vessels building on the Pacific Coast, some of which are lumber schooners having auxiliary propulsion by means of internal-combustion engines. A few of these have been installed and tested out with extremely satisfactory results, and we think that all of those to follow will prove to be equally satisfactory.

There is one recent development that has given greater possibilities, or, at least, greater convenience for the installation of electricity for this purpose, and that is the application of hydraulic variable speed gear to the steering gear. The control of the rudder directly by electric motor is somewhat complicated, and although it has been worked out successfully on battleships, the greater simplicity of operation by means of the hydraulic gear would give it a great advantage in the merchant marine. In this case the electric equipment is extremely simple—it does not require control of the speed of the motor, but merely to start it and let it run at constant speed. The control of the rudder itself is obtained through the hydraulic gear.

The question of the use of alternating current for this purpose is one that is receiving considerable attention at the present time, but this is a matter which can be more definitely discussed a year from now, when some of the equipments now under construction will have been tried out. One advantage is the convenience of running the turbo-alternators at high speed with good economy, whereas a direct-current generator requires either a slow-speed turbine or geared connection. The absence of commutators and the consequent tendency to sparking is an advantage, as has already been mentioned, on vessels carrying fuels or oils which give off inflammable gases, and, furthermore, the absence of commutator brushes promotes convenient and simple maintenance.

I feel that a beginning has now been made more extensive than in the past which will lead forward to a large extension in the development of electrical equipment on shipboard.

The President:—Does any other gentleman wish to add to the discussion?

Mr. R. A. Beekman, *Associate:*—In connection with Mr. Day's remarks about the winches on some of the lumber schooners on he Pacific Coast, I have some pictures here, and I shall leave them on the table, so that any one who is interested can see them, as it may disturb the subsequent speakers if they are passed around.

It also occurs to me to point out that some of the comparisons of the initial cost of electrical installations versus steam have indicated that, when the steam piping is taken into consideration, the electric installation is actually less in cost, particularly if you take a propor-

tion of the boiler cost which must be charged against the steam. This includes the electric generators, wiring, and everything electrical.

One other point Mr. Hibbard mentions is that a couple of steamers at the Pennsylvania Shipbuilding Company's plant are to be constructed with electric propulsion; in addition they are going to control the motors which drive the propellers from the bridge, which is an innovation, never tried heretofore.

The President:—Does any other gentleman wish to enter upon the discussion of this paper? If not, we will ask Mr. Hibbard to close the discussion.

Mr. Hibbard:—I simply wish to thank Mr. Day for his remarks, and for the points which he has brought out as to hydraulic steering gears, the relative merits of alternating-current and direct-current apparatus, etc. The writer has had these subjects in mind for a future paper, which he hopes to prepare.

The President:—I will ask Vice-President McFarland to take the chair and relieve me for a little while.

Chairman McFarland:—Is there any further discussion of Mr. Hibbard's paper? If not, we will extend the thanks of the Society to him.

Personally, I would say I was advised, as a member of the Committee on Papers, that Mr. Hibbard did not have the time to add to the paper some numerical data which, of course, would have made it yet more interesting and made it more valuable for future reference. I hope that he will carry out his idea of giving us another paper and give us such particulars as have been referred to, a comparison of the cost of installation of electric and steam auxiliaries, and also something as to the cost of operation and cost of repairs and things of that sort, in a general way, that will educate us and inform us all.

We will now take up the next paper to be considered, No. 10, entitled, "Submarine Hulls—Comments on Various Types," by Naval Constructor E. S. Land, Member.

Naval Constructor Land presented the paper, and during its reading, said:—

"I wish to make the following addition:—

"After the words 'purpose for which intended' (page 121, fourth paragraph, fourth line): It has been generally believed by a good many of us that the Krupp-Germania boat is a double-hull type entirely, and that is quite erroneous, as there are three different types of hull, one single-hull, one composite, and one double-hull.

"After the words 'dependent upon this factor'—fourth line from bottom of page 125:

" 'When all the facts are analyzed it is rather forcibly brought to the attention of people in the knowledge that habitability and efficiency are interdependent, and while remarkably long cruises are carried out in submarine operation, it has been found necessary to curtail these to reasonably short periods of operation and rather long periods for recuperation.' "

SUBMARINE HULLS.

By Naval Constructor E. S. Land, U. S. N., Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

COMMENTS ON VARIOUS TYPES.

There has always been more or less controversy with regard to the proper type of submarine hull; the subject is unsettled to this day and will probably remain so for many years to come, for submarines are still in the infancy of evolution. Many are the claims advanced as to the original submarine inventor; many and fantastic were the early designs; yet in this, as in the majority of things in this world, it is safe to award the palm to Mother Nature, for she designed the salmon. A casual examination of this interesting fish will show that, so far as hulls are concerned, the contour of the salmon makes a rather good model for a submarine. Combining the model laid down by nature with the imagination and second sight of Jules Verne, we have the submarine of yesterday, to-day and to-morrow.

Without taking up the early designs with which you are undoubtedly familiar, it is my desire to present, in a crude way, the merits and demerits of the types of submarine hulls as they are in evidence to-day. They align themselves into two distinct types—single hull and double hull. However, there are intermediate types that merge on the one hand to the strictly single hull, and on the other hand there are some types in which the double-hull features predominate. Recently there have been developed several types which are practically midway between the single and the double hull. These are known as saddle hulls.

Of the pure single-hull type the best known is the Holland type, which predominates in the American navy to-day and of which there are many examples in other navies of the world.

The double-hull types are well represented by the Laubeuf designs and the Krupp-Germania designs. Of the various types of German boats, some are single hull and some double hull, depending primarily upon the size of the boats and the purpose for which intended. The Krupp-Germania design was evolved to a considerable degree from plans prepared by the French engineer d'Equevilley. Many good features of other types were taken by the Germans. The Laurenti design is generally considered as a true double-hull design; it is not, however, a complete double-hull boat, but is composite in that it is part double-hull and part single-hull construction.

The saddle hulls are more common in the British navy and may be considered more as a development from the Holland design than from any other.

The Lake design, with its watertight superstructure, is properly a single-hull design, but on account of this watertight superstructure feature it is not a pure type of single hull.

The Hay-Denny design, which is well known in Denmark and Holland, belongs to the composite type, combining features of both the single and the double-hull types. Certain parts of the vessel are single-hull construction and other parts are double-hull construction.

There are probably more variations in the single-hull type in the British navy than in any other navy to-day, and these modifications run from the small sponson on either side of the strength hull found on some of the earlier British boats to the real saddle tanks found in the more recent designs, which types approach the pure double hull.

"For submarines, where a good relation between length and breadth is necessary, the cylindrical shape is best, with circular cross-section, diminishing towards the bow and stern and closed off at the ends with a rounded plate. For strength of construction it is necessary that the weight of hull be about 58 per cent of the total displacement, whereas with torpedo-boats, for instance, only about 38 per cent is necessary. In addition to the above, it is necessary to give the boats a relatively greater draught than other craft, and this mitigates against the attainment of great speed on the surface. In about the middle of its length the submarine has a strong tower, which serves as a steering hood and control station."

No matter which type is investigated, the same underlying features generally obtain in all of them, namely, there is one strength hull, the inner hull, which is constructed so as to successfully withstand deep submergence; outside of this strength hull there is generally fitted a superstructure of light plating and light scantlings. This may be non-watertight, as is customary, or watertight as in some Lake designs, or partially watertight and partially non-watertight. The non-watertight space between the inner hull and the strength hull is generally utilized for stowage purposes, to house piping, ventilation ducts, towing lines, mufflers, cables, etc. The watertight portions are utilized for stability purposes, reserve buoyancy and seaworthy qualities. In some types torpedoes are stowed and torpedo tubes are installed in the superstructure, but there are many serious drawbacks to this method of installation and service experience is generally very much against their satisfactory use.

It is understood that the first sponson type of submarines was so constructed from single-hull types to improve the stability of the boats, this being done as an alteration late in the period of construction or after the boats were in service. With this as a beginning, this type was developed so that it appeared in the original design not only for stability and seaworthy qualities but also to permit the installation of broadside torpedo tubes, external ballast tanks, or even oil tanks.

The design of submarines, unlike the design of other vessels of war, has never

gotten beyond the stage of having somebody's name attached to it and, like everybody's watch, the type bearing the particular name is the only correct type according to the designer's opinion. Probably, like the watch, this is approximately true if you apply the correct "equation of time."

In discussing the question of types of hull, it is preferable to analyze as far as practicable the merits and demerits of the pure types, *i. e.,* the single and double hull. If one attempts to cover the intermediate types, the argument is either confused or entirely lost, as in the nature of things these intermediate types partake of the advantages and disadvantages of both in a relative degree, depending upon which type the intermediate most resembles.

It is well to indicate here that any discussion of types and development of types will be given in a general way without any attempt being given to go into details which might be considered in any way confidential. Neither should the statements be construed as a criticism of or advocating any particular design. Accurate information relative to details of submarine construction is difficult to obtain. It has always been more or less enshrouded in a veil of mystery—probably very unjustly and very unnecessarily so.

It seems likely, because the main operations of a submarine take place out of sight, that the average man enjoys carrying out this water veil of secrecy and invisibility to rather absurd extremes. Be that as it may, the tendency to deep secrecy still obtains and information that may be available is not permitted to be published, though a careful examination of all the chaotic literature on submarines will readily show that the so-called secrets of submarines are like the old maid's secret, "yours for the asking." Possibly, like some well-known breakfast foods, "There's a reason."

For the sake of clearness, it may be well to advance the arguments of one side and then the other, placing them in juxtaposition. In order that the advantages and disadvantages of single hulls and double hulls may be considered, the following comparisons of the two types of construction are made. These comments contain some of the arguments advanced by the builders of the different types of boats, as well as additional comments relative to the merits and demerits of the two types. As might be expected, the points at issue are subject to differences of opinion.

DECK SPACE AND FREEBOARD.

Double Hull.—Increased deck space and deck height, which provides some means for the crew to get a little fresh air, and a small amount of exercise; this increases the habitability factor of the boat. Habitability is a vital factor in a sea-keeping submarine. Efficiency of personnel is directly dependent upon this factor.

Single Hull.—The type of vessel does not necessarily affect either the width of the superstructure or the deck height; the single-hull design can be arranged to

give the same results in this respect as the double-hull type of vessel. In some standard designs the width is practically the same for both types.

STRENGTH.

Double Hull.—Since all diving tanks are outside the pressure body, the inner hull has a smaller diameter and greater strength.

Single Hull.—Double-hull boats are usually designed for about 150 feet depth test (foreign requirements) and single-hull boats for 200 feet. As far as it can be calculated, the margin of safety in single and double-hull boats is the same; if there is any difference it is probably in favor of the single hull.

As actually built the steel weight for a double-hull boat of 150 feet depth test is approximately the same percentage of light displacement as that of a single-hull boat of 200 feet depth test. In other words, for the same strength, the double hull is heavier.

FORM, AS AFFECTING SURFACE, SPEED AND SEAWORTHINESS.

Double Hull.—Better stream lines are possible; hence, less resistance is offered to surface propulsion, and a more seaworthy boat can be obtained.

Single Hull.—Up to a speed of about 16 knots for boats of 800 tons or 14½ knots for boats of 500 tons single-hull models drive easier than the double-hull models. The present single-hull models are designed for moderate speeds and the double hulls for high speeds. It is the opinion, however, that the difference as noted above would still obtain, but in a lesser degree, with single and double-hull boats each specially designed for the same speed. Structural and space requirements usually prevent the use of a small longitudinal coefficient in a double-hull design, so that a practicable double-hull boat probably cannot be made to drive as easily as the single-hull at moderate speeds.

As regards sea-worthiness it is considered that single-hull designs have proven that they are seaworthy, in fact very much more so than some designs of the double-hull type.

FUEL TANKS.

Double Hull.—Fuel tanks may be installed outside the strength hull, giving greater capacity for fuel, hence greater cruising radius. As these outside fuel and diving tanks have their pressure equalized with the outside water pressure, they can be blown out much quicker in case of an emergency, and greater reserve buoyancy obtained quickly.

Single Hull.—There is no choice between double and single hull in this respect. Fuel can be carried in ballast tanks of single-hull boats as well as in double-hull types. The question of fuel being "outside the strong hull" is not material, since the inner wall of the ballast tanks in the single-hull boat is tested to the same pressure as the hull itself.

In the single-hull type the internal walls of ballast tanks are tested to the same pressure as the hull itself, and the main tanks are therefore capable of being blown at any depth which the hull will stand. As regards time to blow ballast tanks, this is in favor of the single-hull type. Kingstons of single-hull boats can be made larger in proportion to tank volume, and construction offers less resistance to rapid flow of water in the tanks.

SEA-KEEPING QUALITIES.

Double Hull.—Comparative tests between the two types under discussion, conducted by the French, showed the superiority of the double-hull type over the single-hull type in "necessary qualities for all prolonged navigation at sea."

With regard to "sea-keeping qualities," a service comparison of boats in our service (L class and M class) would be of value.

ARMAMENT.

Double Hull.—Superior in offensive qualities.

Single Hull.—Single-hull boats may have the same armament as double-hull boats of the same displacement.

BUOYANCY.

Double Hull.—As double-hull types usually have about twice the reserve buoyancy of single-hull types, they are much safer. Reserve buoyancy is an essential requirement for sea-worthiness.

Single Hull.—Single hulls have less reserve buoyancy than double-hull boats. The outer hull in way of ballast tank is, however, stronger in the single-hull design, and it is considered for this reason that this type of vessel is as safe as the double hull. The reserve buoyancy for single-hull designs is real, whereas the reserve buoyancy on certain double-hull vessels is partly theoretical.

SAFETY IN CASE OF COLLISION.

Double Hull.—The outer tanks offer a protection in case of collision, as they are filled with sea water, and the shock does not come directly on the pressure body. This is true in case the collision happens in way of the double-hull portion of the boat, and it is not of sufficient force to penetrate the inner shell. Since the outer hull is of comparatively light construction, its absolute value in this connection is open to question. The chances are that, if the outer hull is damaged, the inner hull will be injured also. The space between the inner and outer hulls is not filled with water when the vessel is on the surface, and collision happens generally on the surface.

If the outer tanks are filled with water or oil, this will transmit the pressure of an explosion to the strength hull, and the protection offered is more theoretical

than real, but if the tanks are empty or only partially full, a genuine protection is offered against depth bombs, mines, etc. This is a matter of considerable importance in warfare as carried on to-day.

SUBMERGED RESISTANCE.

Double Hull.—These craft possess the possibility of greater submerged speed on account of the smaller resistance, due to the better form of hull. So far as authentic records go, these possibilities have not been realized.

Resistance curves of two boats, one a double-hull boat, the other a single-hull boat, made from experiments extending over a period of years, gave the following results:—

	Tons	*I.H.P.*	*Surface*
Double hull....	327	1,400	15.8 knots.
Single hull....	334	1,400	13.4 knots.
			Submerged
Double hull....	327	480	9 knots.
Single hull....	334	480	9.5 knots.

These tests were reported by Mr. G. Berling of Kiel.

Single Hull.—For boats of the same surface displacement, experience indicates that submerged resistance is in favor of the single-hull design. The actual shape of model for submerged running makes comparatively little difference. The increased resistance of the double-hull type is due to the increased submerged displacement, and consequently increased wetted surface.

DISADVANTAGES OF THE DOUBLE-HULL TYPE.

(*a*) The hull tanks are of course weaker than the spindle hull, and it would be dangerous to pump tanks when deeply submerged.

(*b*) A very large metacentric height is necessary in the light condition in order to obtain a safe metacentric height while submerging, and when submerged; otherwise the stability approaches zero when trimming down.

(*c*) A large metacentric height will probably give us a stiff boat whose surface activities in a seaway will resemble those of a destroyer. This may be relieved by bilge keels.

(*d*) In a double-hull type the effect of the free ballast water is more profound than in the single-hull type, because in the former the weight and moment of the ballast water are larger than in the latter.

ADVANTAGES OF SINGLE-HULL TYPE.

Simplicity of Construction.—The single-hull boat is undoubtedly much simpler to construct. The main ballast tanks occupy a shorter relative space in the boat

and access in the tanks is much better for construction, cleaning and painting. The simpler construction makes it possible to build or repair the single-hull type in a much shorter time than a vessel of the double-hull type.

Lighter Weight.—From actual experience it appears that hull weight of a single-hull boat for 200 feet submergence is the same as that of a double hull for 150 feet for same light displacement, and therefore a double hull for 200 feet depth will be heavier. Except for boats of high surface speed, the single-hull boat has thus a balance of weight in its favor which may be used for other purposes.

The single-hull boat, having less reserve buoyancy, will require less air for blowing tanks, so that a further weight is available for improving military qualities.

A single-hull boat will require less displacement to fulfil a given program of speed, radius, armament and depth test, in view of weight savings indicated herein.

Time to Fill Tanks.—In view of better access in ballast tanks the single-hull type will flood quicker than the double hull with same relative size of kingstons. This objection to the double hull might be overcome by further subdivision of the main ballast, and operating a part of the kingstons from stations forward and aft (probably at forward end of battery and after end of engine-room). The tanks on single-hull boats are lower and therefore the mean hydrostatic head is greater while filling. This advantage can only be overcome on the double-hull boat by the use of larger kingstons.

The above arguments will no doubt be considered as confusing rather than as clarifying the situation, but, as indicated earlier in the paper, these are the arguments advanced and answers given by the advocates of the types under discussion. If the size of the boat is considered, there will come a dividing line beyond which the double-hull type has many important advantages over the single hull. The problem therefore reduces itself primarily into deciding where this dividing line is. There can be little question but that, for boats up to 600 tons surface displacement, the advantages of single-hull predominate; from 600 tons to 800 tons there is little to choose from; beyond 700 tons it appears that the double-hull boat has the call and, when greater displacements than 800 tons are considered, the advantages of double-hull boats for work with the fleet greatly outweigh the advantages of the single-hull type.

The lines of the hull lend themselves much more readily to high surface speed requirements; in fact destroyer lines can be approximated; there is more deck room; there is greater freeboard; greater surface cruising radius is available; better gun platforms and working circles can be obtained; hull strength and depth test can readily be made to equal that of the single hull; greater safety is obtained, not only against serious damage on account of collision, both surface and submerged, but also against mines, depth bombs, and surface and submerged shell fire.

It may be of interest to note that comparative tests were made not very long ago in which three types of boats (one single hull and two double hull) were built at the same time and by the same country. Unofficial reports indicated that the results of these tests were very much in favor of the single hull. This was quite

a surprise to many interested in the two types, as the inference was that the conclusions were generally applicable to submarine construction, but, when the facts are analyzed, it appears that the boats are all less than 400 tons displacement, so that the results of the tests are not at all surprising.

The question of stability in submarine design is one that is necessarily handled with great care, for the designer is working with inches where his brother ship designer works with feet. In the single-hull type we find a small surface G. M. and a considerably larger submerged G. M.; in double hulls, on the contrary, we find a large surface G. M. and a comparatively small submerged G. M. In trimming we are lucky if we find any G. M. at all in either type, especially after the boats have been in commission a few years and various changes and alterations made. These changes are always additive. It is a rare sight to see a recommendation to eliminate anything from these over-congested craft.

There is little to choose from in the two types when it comes to this question of stability, for in a double-hull type one fights shy of too much metacentric height on the surface for fear of getting a "heavy roller," yet clings to a comparatively large surface G. M. in order to have even a very few inches while trimming and a few more when submerged.

In the single hull the designer is constantly fighting to obtain the necessary inches for his surface G. M. in order that he may not have a crank vessel and in order that he may have those "very few inches" while trimming.

With more recent types, where displacements are around the 800-ton mark, it is becoming increasingly difficult to equip a single-hull boat with the armament and equipment desired and yet retain the requisite surface stability.

Last year the Society was informed that the tendency of the U. S. Navy was to continue the policy of building small submarines of about 400 to 500 tons' surface displacement. It is apparent that this policy has been modified during the year, and the 1918 program of submarines calls for nothing but the 800-ton type. This is believed to be a great step in advance. Moreover, it is a step that is amply justified by a study of building programs and war conditions abroad.

Foreign tendencies, according to the newspapers, appear to favor much greater displacements, and we hear of 2,000-ton, 3,000-ton and 5,000-ton submarines. Some of them are actually in existence, but is this a tendency of construction or an experimental move? Is it a fixed policy or a freak opportunity? Not being a prophet I cannot furnish the answer, but I venture the prediction that the great preponderance of submarine construction going on to-day in the navies of the world is in the vicinity of the 800-ton type—a type that I believe is the most useful, all-the-year-round type of submarine. What the future holds no man can tell, but I will venture one more prediction—before this war is over the submarine will be found to be the best antidote for the submarine.

DISCUSSION.

THE CHAIRMAN:—This most interesting paper is before you now for discussion. We should be glad to hear from any of the experts present who have any views to offer. I presume that Naval Constructor Land will be very glad to answer, so far as is compatible with his not divulging secrets, any inquiries that are made.

ASSISTANT NAVAL CONSTRUCTOR A. W. CARMICHAEL, *Member:*—I would like to ask Naval Constructor Land, if he is permitted to say, whether the latest and largest German submarines are of the double-hull type.

NAVAL CONSTRUCTOR LAND:—From all information available, I understand they are. I do not think it is any secret, for all of the larger submarines are of the double-hull type. The composite type and the single-hull type are small boats, considerably smaller in size than anything we consider as the ordinary "U" boat.

MR. B. STROONNICOF, *Member:*—I must apologize for mutilating the English language, because I speak it very poorly. I would like to ask Commander Land about some little information—first, on page 127, he says that some comparative tests were made not very long ago in one country. It may be of interest to inquire if this information about these tests is published in some periodicals, and if this information is of technical interest, that is, whether it contains sufficient data on which to base conclusions.

Then I would like also to point out what is referred to on page 122. Here we see the statement that it is necessary that the weight of hull of submarines shall be about 58 per cent of the total displacement. I think in the case of some of the newest boats, with a displacement of over 600 tons, calculations are made more rationally, and if these calculations are proved by actual experience with diving tests, this number may be made lower, a little more than 50 per cent, or perhaps even only 50 per cent.

THE CHAIRMAN:—Is there any further discussion? If not, perhaps Constructor Land will answer the question just asked.

NAVAL CONSTRUCTOR LAND:—With regard to the first question, I am unable to give you any information as to whether these comparative tests on the three boats were ever published. I have never seen any publication of them. The information came to me in an unofficial manner, so far as the Navy is concerned, and not confidential so far as the personal side is concerned. I felt I had a right to make some comment on it, because it was extraneous to the Navy Department, but I have no right to make any further comment, and as it is a matter of controversy I can only say what I have said here and leave the rest for the future to bring forth. Unquestionably that will come forth some time after the war is over and competition in submarine construction begins again, instead of being localized in each country; at that time I think the results of these tests will come out and probably highly ameliorating circumstances will also be made known.

I do not think the tests were thoroughly carried out because they were made, as I said, by one country, and the representatives of the other countries concerned, if you put it on a national basis, had practically nothing to do with it; I do not know that they even had any representatives there, but the results, indicating single hulls are the only thing for all boats, have to be taken with a grain of salt.

With reference to the second question brought out by the gentleman, referring to the matter on page 122, he will see that is in quotations, and it is quoted from a paper by Mr. Berling of Kiel, published in 1913 or 1914. You are quite correct in your modification. I did not attempt to bring these figures down to modern practice, because I know that information is considered confidential by the Navy Department at the present time.

Mr. Marley F. Hay, *Member:*—I have read with much pleasure the delightfully whimsical and argument-provoking paper by Naval Constructor Land on the subject of Submarine Hulls, regretting only that the analysis was not carried to a point where we could determine the preference of the author. He has confined himself to a comparison of the pure single and double-hull types, leaving the intermediate composite type to take care of itself.

The statement is made that "In the nature of things," these intermediate types partake of the advantages and disadvantages of both in a relative degree, depending upon which type the intermediate most resembles. I feel that it is possible to design a compromise between the pure single-hull and pure double-hull which should combine the advantages and eliminate the disadvantages of both. In my own paper I have stated in another connection that a compromise is not compatible with the highest requirements of either and is likely to entail the weak points of both and the preeminent advantages of neither. There may be an apparent inconsistency in these two statements, but I think it will be clarified if it be explained that in the former case we are aiming at one objective which can best be attained by a combination of the advantageous characteristics of single and double-hull vessels, whereas in the latter case we have two different objectives in view which cannot be amalgamated without a direct sacrifice of some of the major characteristics in either one direction or the other. In fact, if one scrutinizes the disadvantages of pure single hull, it will be found that it is inherent in what might be called the single hullness of the design and conversely the disadvantages of the pure double hull are likewise in proportion to the thoroughness with which this principle is carried out.

In the comparison of the two types in Mr. Land's paper, under the caption, "Deck Space and Free Board," the author himself states that there is no choice.

Under the caption of "Strength," the conclusion is reached that for the same strength the double hull is heavier. This is due to the fact that the weight of hull is based upon a percentage of the light displacement in each case. This is not quite a fair comparison, because the double-hull vessel has much larger ballast tanks, consequently greater reserve buoyancy, which is considered an advantage as compared with the single hull. If the hull weights in each case were referred to the submerged displacement, it would probably be found that the advantage of lightness for the same strength would rest with the double-hull vessel.

In considering the two types from the structural point of view, the pure single hull is much simpler than the complete double hull. In all complete double-hull vessels a point is reached where the two hulls approach each other so closely that a perfectly impracticable construction has to be resorted to in order to carry out the principle to its logical limit. If this extreme carried with it any particular advantage, there might be some excuse for con-

structional abortions, but the fact of the matter is that the capacity of the ballast tanks, and consequently the reserve buoyancy, becomes so great and the demand upon the total available weights so excessive that other and more important military qualities have to be sacrificed, and artificial measures have to be adopted to reduce the metacentric height in the light condition to practical proportions.

A ready expedient for accomplishing both of these purposes has been devised in the German and Austrian submarines by allocating a part of the space between the two hulls above the light water-line to fuel tanks. This ameliorates one difficulty by the introduction of another. It may appear superficially to be a satisfactory solution, but closer examination will indicate that such is far from being the case. As the outer wall of these tanks is not adapted to withstand external pressure due to the depth of submarine, the fuel tanks must be in communication with the sea when the boat is submerged. On the other hand, as they are above the light water-line when the vessel is on the surface, they must not be in communication with the sea in that condition. Otherwise the tank would be self-baling and empty itself. Arrangements must be made, therefore, to have it in communication with the sea in one condition and not in communication with the sea in the other, a matter which might conceivably be overlooked in these days when expeditious submergence is a matter of life and death.

From the point of view of seaworthiness and stability, which is one of the principal differences between single and double hulls, it will be seen that the single-hull vessel on the surface has just enough matacentric height and no more, whereas the double-hull vessel is liable to have excessive metacentric height. In the submerged condition the single-hull vessel has a considerable surplus of metacentric height, whereas the double hull is fortunate to have just sufficient. Under these conditions, it would seem that a composite hull having a somewhat greater G. M. than the single hull and a lesser G. M. than the double hull on the surface, with conditions reversed in the submerged condition, offers greater possibilities of a satisfactory all-round character than the pure form in either case.

From the practical structural point of view the desirability of eliminating impossible tank construction requires no argument for any shipbuilder. The author is undoubtedly justified in stating that below 600 tons the arguments in favor of the single hull predominate, not because of theoretical considerations, but purely from the structural point of view.

Naval Constructor William McEntee, *Member*:—At the bottom of page 127 Mr. Land states, among the advantages of the double-hull type for submarines, that the "hull strength and depth test can readily be made to equal that of the single hull; greater safety is obtained not only against serious damage on account of collision both surface and submerged, but also against mines, depth bombs, and surface and submerged shell fire." I am willing to grant readily that the double-hull construction does offer advantages against collision on the surface, but if the tanks exterior to the strength hull are filled with water, I cannot readily see where the double-hull construction has any advantage, when it comes to protection against a depth bomb, because the depth bomb acts really from pressure, and in another part of the paper the statement is made that the single-hull type of equal hull weight can stand a larger depth test—in other words, must be stronger against pressure. If the tanks themselves are filled with water, the pressure is transferred immediately from the light exterior hull to the interior strength hull, and if the pressure is sufficient to crush the hull, it seems to me in either type you must depend on the strength of the interior hull.

THE CHAIRMAN:—I ask Constructor Land, if it is compatible with the rules of the Navy Department, and if the information is not unreasonable to ask, to tell us something along these lines—a question which I imagine has occurred to many of us who do not know very much about the operation of submarines—we hear so much about the possibilities of much larger submarines being built, that are going to be, for instance, cruisers and all that kind of thing. We know that they must be a great deal longer than the ones used now, and it would occur to even a layman that they would be more difficult to operate than the others. What I desire to ask is, about what is the minimum depth of water in which a submarine can safely operate, and suppose they do increase the size of the boats, and make them, for instance, say, cruisers up to 2,000 tons, what would be their length, and about what depth of water would they require to operate safely? I think we would all like to know that.

NAVAL CONSTRUCTOR LAND:—I think I can answer some of these questions without overstepping the bounds of propriety. The diameter of the hull of a 600-ton boat ranges, depending upon types, somewhere between 16.5 to 19.5 feet. The depth of water that this boat requires to operate in is a relative one. With older types of submarines, with fixed external fittings, in the way of masts, stanchions, periscopes, fair waters, etc., it requires, even for a small boat of this type, somewhere between 40 and 50 feet depth of water to operate in; with certain boats I have seen they would then have to crawl along the bottom, so to speak—at times they would be navigating pretty close to the bottom.

With modern boats, which have means of telescoping, housing or otherwise getting rid of their superstructure excrescences of all kinds, the depth of water in which they can successfully operate is considerably less than it was formerly. I have no accurate figures on any such operations of this type of boat, because I do not think any nation has published any such information, but the distance from the keel to the highest point of the periscope fair water ranges from 28 to 38 feet, and the variation is not very great, even when the size of the boat is very materially increased. In increasing the size of the submarine, she runs very rapidly to length—more rapidly to length than to any other dimension—and some of us feel that the future limitations of actual submarine craft may be dependent upon that fact. However, that is something the future will take care of, for it is possible, as we know, that we can take some of our tankers and whalebacks, and by a little more closing up they would become semi-submersibles.

As to the second question, about the approximate length, diameter and characteristics of these larger boats, I will not attempt to go into any detail, but will say, roughly, that they run from 320 up to possibly 400 feet, and the diameters of the boats vary from 20 to 24 feet. The length will run from, say, 150 to 170 feet for a 500 or 600-ton boat, and the diameter is 15 feet to 18 feet. The diameter of the 2,000-ton boat is only increased by a small percentage, say from 20 to 23 feet, while the length is more than doubled.

THE CHAIRMAN:—Does not the great length make it difficult to operate in relatively shallow water, and would not there be danger of the boat sticking her nose in the mud, the danger of which in a shorter boat would not be very serious, but in a longer boat would be quite serious? Would it not require a much greater depth of water to operate long submarines than it would to operate shorter ones?

NAVAL CONSTRUCTOR LAND:—Not much greater. The statement has been made that

the long boat is much more difficult to operate than the short boat. I do not think that is capable of substantiation in its entirety. I think any mass of matter going at considerable speed, the larger the mass the more difficult to control—I make that just as a flat statement. Now these conditions and statements are relative. Take a small automobile and compare it with a large one, and you can control the heavier one easier than you can the lighter one. The difficulty of operating a submarine in reduced depth of water is purely one of the distance from the keel to the highest point of the boat, and that is greater, naturally, in the larger boat, but greater in a very much smaller degree than one would expect.

THE CHAIRMAN:—Do you think the length would not make much difference?

NAVAL CONSTRUCTOR LAND:—With proper control, with the horizontal stern rudders and such forms of hydroplanes as may be found on these long boats, you can get, under favorable weather conditions, a nicety of control that is quite surprising. There seems to be very little difficulty—under favorable weather conditions, I mean—in controlling these boats, not only accurately but at extremely low speed, at speeds you would not consider steerage way in a surface vessel. That is not only true of the enemy's boats, but it is also true of the allied boats—they are also doing that.

We do not know, of course, just what difficulties will obtain with the longer boat, because there are not any instances in which tests of that kind have been made, or if there are any such instances they have been in existence such a short time that no data are available, but I think that the submarine officers anticipate very little difficulty in operating the long boats.

THE CHAIRMAN:—I am personally much obliged to you for your explanation—that is exactly what I wanted to get in the way of information.

NAVAL CONSTRUCTOR LAND:—I will say in Mr. McEntee's absence—he has just left the room—that the point he raised against my line of argument in regard to the layer of water between an outer and inner shell is one which has caused not only the Navy Department, but the shipping industry of the whole country, many hours of debate. There is no question but what Mr. McEntee is correct in the statement that the pressure is transferred. We all realize that, but if you have frames, even though they are light frames, longitudinals, webs, brackets, and what not, between the outer hull and the inner hull, there is some merit in having the layer of water, oil, or whatever it may be. We work on the fact that water is incompressible, but, nevertheless, there is some factor of safety; what this factor is, I do not know, but I know there is some factor of safety, and it is demonstrated from the reports received from abroad, that the double hull does afford some protection.

There is always a certain amount of air in the water. There may be air-pockets in the compartments, and frequently there are air-pockets in the compartments, so that there are some conditions existing that afford a means of protection; there are a number of cases on record where the outer hull has been damaged and the inner hull has not been damaged. Further than that, I am not prepared to make any statement, but that is correct.

THE CHAIRMAN:—Do you care to comment on Mr. Hay's remarks, Captain, and in general on the other comments which have been made on your paper?

Naval Constructor Land:—I might answer Mr. Hay's remarks along this line—that the paper was purposely written as it is; I knew full well the shortcomings of the paper, in leaving out the composite type. My only regret, not only in regard to Mr. Hay's comments, but for general reasons, is that more submarine builders of the country are not here to take part in this discussion. The idea I had in writing this paper, to use the phraseology of the street, was to "start something"; to get a little controversy and throw a few sidelights on submarine construction in this country, but apparently our submarine friends are too busily engaged in building submarines to attend this meeting.

Mr. Hay picked out the weak point of the paper, so far as concerns my personal opinion as to the composite boat, but that was more or less required by the circumstances which surround me, and I think, like Commander Taylor, while I do not feel that free speech is forbidden to men in uniform, it is wiser to refrain from making statements too freely; I should prefer not to make any comments as to my personal convictions, due to the position that I hold at present in Washington, in connection with submarine design.

The Chairman:—Gentlemen, I am sure you will all wish me to extend the thanks of the Society to Captain Land for his interesting paper. We have enjoyed very much the presentation of the paper and the valuable discussion which it has brought out.

If there is no further business to come before the meeting at this time, we will take a recess until 2 o'clock this afternoon.

The meeting then adjourned.

FOURTH SESSION.

FRIDAY AFTERNOON, NOVEMBER 16, 1917.

Vice-President McFarland called the meeting to order at 2.15 p.m.

THE CHAIRMAN:—In place of one of the papers which was to be presented this morning, there were some remarks with respect to the duty of every patriotic citizen to do all things possible to aid in insuring victory for our arms. We moved so quickly this morning, and there was such a limited attendance, the matter did not get as far as we wanted it to go. During the recess we talked the matter over, and there is further action which it is desired shall be taken. I will now call on Mr. H. A. Magoun, vice-president of the New York Shipbuilding Company, to say a word.

MR. H. A. MAGOUN, *Member*:—Mr. Chairman and gentlemen, I wish, with your permission, to offer this resolution:—

"Having in view the trying period through which our country is going, and the vital necessity of hearty patriotic cooperation by every class in the community; and

"Having in view the intimate relations of employer and employee between the members of this Society,

"*Resolved,* That it is the sense of this meeting that the Council be asked to formulate suitable resolutions to the President of the United States, assuring him of our loyal support in every way, and especially endorsing his earnest efforts to arouse the patriotic enthusiasm of labor, organized and unorganized, to put forth every effort to insure the victory of our arms."

MR. CHARLES P. WETHERBEE, *Member*:—Mr. Chairman, I move that the resolution be adopted.

The motion was seconded.

THE CHAIRMAN:—Does any gentleman desire to say anything on the subject? If not, all in favor of the resolution will say "Aye"; opposed, "No." It is unanimously carried.

The secretary will please advise the Council of the action taken.

We will now take up paper No. 13, entitled "Fabricated Ships," by Mr. R. H. M. Robinson, a Member of the Council. In the absence of Mr. Robinson, the secretary will read the paper.

The acting secretary presented the paper.

FABRICATED SHIPS.

By R. H. M. Robinson, Esq., Member of Council.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

Recently the term "fabricated ships" has become one of public interest. A fabricated ship may be defined, briefly, as a ship on which the work of punching and shaping the plates and shapes and, to some extent, assembling and riveting, is done in a fabricating shop, ordinarily employed for bridge or tank work, as distinguished from the usual practice of doing it in a shipyard punch shop.

So far as the writer knows, the fabricated ship is a product of American progressiveness. The writer claims no credit for the idea or for its development and hardly knows why he should prepare a paper on the subject unless it be that he has the honor to be connected with two companies now constructing ships on this system, one of which may reasonably claim to be the first to do so.

The principal credit for carrying out the fabricating idea is due to Mr. C. P. M. Jack, now consulting engineer, and to Mr. Max Willemstyn, engineering manager of the Chester Shipbuilding Company and of the Merchant Shipbuilding Corporation, and it would be improper to neglect to state that the ideas of Messrs. Jack and Willemstyn could probably not have been carried out, except for the interest and assistance given them by Mr. Jas. A. Farrell, president of the U. S. Steel Corporation, and by the officials of the American Bridge Company.

The construction of fabricated ships makes it possible to have the steel work done by those who are specialists in the line of fabricating steel with all of the special tools and labor-saving devices at their disposal.

It relieves the mind of the shipyard operator from the multitude of detail that goes with such work, reducing his problems to those of engineering, erection, riveting and assembling by the workmen, and to the installation of other units of outfit and equipment.

The type of ship which the Chester Shipbuilding Company has built, and which it and the Merchant Shipbuilding Corporation are now building, provides for the use in all places of conventional ship shapes and ship plates, subject to the rules, inspection and survey of the registration society, both as to quality and material, dimensions, riveting and other matters. These vessels are cargo carriers of about 8,800 to 9,000 tons dead weight capacity with poop, topgallant forecastle and bridge, the latter being about 124 feet long. The decks, with the exception of the poop and topgallant forecastle, are without sheer at the center line. Complete double bottom for the carrying of fuel oil or water ballast is fitted. The machinery is located amidships and consists of high and low pressure turbines driving a single screw through reduction gears.

In the emergency which has recently arisen there have been proposed ships constructed from bridge shapes and universal mill plates with regard to which the writer has no personal detailed knowledge. It would appear to him that there might arise certain difficulties in using this character of material in the construction of ships, but he would prefer to leave to those who are personally cognizant of the matter any questions in regard to this.

During the late winter of 1912 there was a sudden demand for oil tankers, while freight charters were low and cargo ships plentiful, and almost anything which could be made into an oil tanker was used. Mr. Jack then conceived the idea of using a system of vertical cylindrical tanks which were to be built and tested ashore, then installed bodily in the steamer.

Two cantilever type colliers, the Borgestad and Fritzoe, were acquired under long-term charter. Contracts with Pittsburgh tank builders and New York pipe fitters and shipwrights were entered into. The tank builders started to erect the steel (amounting to about 900 tons) long before arrival of the steamer, and by June the loading of the tested tanks in the Borgestad was begun and the actual loading was finished in ten days.

It is needless to say that almost insurmountable difficulties had to be overcome—in the first place, on account of the use of cylindrical tanks for ships; secondly, because of the manufacture of these tanks by tankbuilders, the riveting by housesmiths and several other "objectionable" features which were not done according to old-time custom.

Mr. Jack, during this time, spent several months in Norway to adjust matters with the classification society and had to withdraw the second ship from their class and change to Lloyds.

The first ship sailed in September, 1913, without class, which was only again assigned after a trial of three months.

During 1913 the Escalona, then building at a British yard, was changed into a cylindrical tanker, but, due again to difficulties of classification, horizontal tanks were installed. These tanks were also manufactured and tested complete outside the shipyard.

In the fall of that year three ships were started in Great Britain on the general design of the tankers now building at Chester, but the shipyard would extend the fabricating portion only to the cylindrical tanks.

In 1914 the Chris Knudsen and the Mills were converted on this side. The former was on the type of the Borgestad. A new departure was made with the Mills. The tanks in this ship were connected to tank-top and deck, a trunk built on deck and connections made from tank to tank and to the ship's side, thus forming cylindrical tanks and spaces between tanks and shell with oil-tight center line bulkhead between tanks. Practically all the material was ready for assembly when shipped from Pittsburgh. All holes were punched and countersunk, and stiffeners riveted to trunk sides, center line, etc., wherever possible before shipping. The only pieces which were left blank were the outstanding leg of bounding angles connecting to the old ship's structure, and one edge of the transverse bulkheads.

On account of the peculiar dome roof construction of tanks, which dome formed into a rectangular trunk, only about 60 per cent of the material was multiple punched and the balance single punched.

The ships converted at New York were all erected with regular tank builders' outfits, consisting of a gantry or stiffleg derrick, air compressor outfit, blacksmith's forge and one or two shipfitters. All piping, ventilating, etc., was fabricated beforehand, except the closing pieces.

The above experience is given in some detail as it was gradually leading toward the fabricated ship, but in taking up the fabricated ship as a whole another difficulty arose on account of the size of the job involved in fabricating complete ships, involving thousands of tons of steel instead of hundreds.

The tank manufacturers previously engaged could not entertain the proposition, and others were quoting prices which made the undertaking impossible commercially. The American Bridge Company, however, after several months of search and discussion, decided to fabricate two ships, but would only undertake to do the absolutely parallel midship body.

About 60 per cent of the total steel weight of the first two ships was thus manufactured. This was increased to 70 per cent on the following ships, and to-day the bridge shops have contracted for 85 per cent of the hull steel and will fabricate also part of the curved portion of the ship.

Of course a 100 per cent fabricated ship is possible, but with the present bridge-shop equipment this is not obtainable. They will first have to increase their furnace facilities to take care of the bending of frames and the bevelling of angles, which may be done in the near future if the standard ship is here to stay.

The manufactured ship is a commercial possibility only if duplicate ships are built and, therefore, this policy was adhered to as far as possible from the beginning in contracting for the ships at Chester, there being but four different classes. These classes are as follows:—

1. Tank ship of about 9,000 tons d. w. capacity, fitted with cylindrical tanks on Jack's system. The vessel is built with topgallant forecastle, poop and short bridge. The main deck at center line and top of expansion trunk are without sheer. Cylindrical tanks extend from tank top to under side of main deck, and a continuous trunk extending between poop and topgallant forecastle takes care of expansion and provides a working deck between the bridge, poop and forecastle decks. Machinery is located aft and consists of a high and low-pressure turbine driving a single screw through reduction gears.

2. Two-decked freighter of about 8,800 to 9,000 tons d. w. capacity having poop, topgallant forecastle and bridge, the latter being about 124 feet in length. This vessel is built with sheer. Complete double bottom for the carrying of fuel oil or water ballast is fitted. Machinery is located amidships and consists of high and low-pressure turbines driving a single screw through reduction gears.

3. Shelter-deck freighter of about 9,300 tons d. w. capacity, having poop, topgallant forecastle and bridge. Complete double bottom for the carrying of fuel oil

or water ballast is fitted. Machinery is located amidships and consists of high and low-pressure turbines driving a single screw through reduction gears.

4. Two-decked freighter of about 8,800 to 9,000 tons d. w. capacity, having poop, topgallant forecastle and bridge. The decks, with the exception of the poop and forecastle decks, are without sheer at the center line. Complete double bottom for the carrying of fuel oil or water ballast is fitted. Machinery is located amidships and consists of high and low-pressure turbines, driving a single screw through reduction gears.

Except as to details which may be modified to provide for ease of fabrication, the fabricated ship does not differ essentially in structure from any ship of a similar class. One of the prime questions involved is that of multiple punching.

The greatest difficulty with the arrangement for multiple punching lies in the fact that the minimum distance from center to center of punch dies in a multiple punch is regularly 2 inches, which distance can occasionally be reduced to 1⅞ inches.

The term "multiple punch" implies that the spacing of rivets is to be laid out so that the spacings of rivets in different successive rows are in multiples of each other or in multiples of 2 inches. Take for example a butt spacing of four diameters of ⅞-inch rivets equal to 3½ inches. The frame riveting in this case could be six diameters or 5¼ inches, which is no multiple of 3½ inches, and neither is 3½ inches a multiple of 2 inches.

A compromise is made in this case by making an average butt-spacing of 3½ inches, which can be done by spacing in groups of three, viz., 3¼ inches, 4 inches, 3¼ inches. The punches for the butt and frame spacing would be spaced in the machine as follows:—3¼ inches, 2 inches, 2 inches, 3¼ inches. The first, second, fourth and fifth punches would be used for the butt-spacing; the first, third and fifth for the frame spacing, allowing for a 5¼-inch spacing.

Where the butt spacing is 3½ diameters and the frame spacing 7 diameters, such as on smaller size ships, there is not much trouble, but the multiple punch is hardest to apply on the 9,000-ton, clear-hold, single-deck ships, with their 5½ and 6 diameters frame riveting. Again, on the larger ships with 4-inch butt-spacing it is easier to be according to rule, and it should be here noted that Lloyds Register of Shipping has been very progressive and broad-minded in allowing the use of the average spacing instead of the strict and absolute adherence to stated rules.

The first thing to do on a ship designed for multiple punch is to arrange the midship section in such a way that all longitudinal rows of holes fall in line with the principles just explained; second, to arrange the plate width so that the greatest number of equal width plates are obtained; third, to see that, if possible, each plate is symmetrical about the long center line of the plate, so as to avoid any possible counter-sinking errors. No templates are required for setting the multiple punch, which is entirely done from the typical rivet spacing drawing.

In staggered riveting, the minimum longitudinal spacing between the rivets of one row and those of the other is 1 inch, but 1⅛ inches is preferable. This space is

required for the stops and pawls, which stop the table during the downward stroke of the punch-head. It is of course possible to reduce the minimum space to small fractions, but then the human element of error is introduced, as a man has to insert a liner between stop and pawl, equal in thickness to the change in spacing wanted. Otherwise the machine is electrically controlled, except the throwing in of the clutch for punching.

A "pole," being a batten about 3 inches wide by ½-inch thick and of such length as is required, is used as template for the longitudinal spacing. Steel stops are inserted in the holes of the batten corresponding with rivet spacing, or, on the newest machines, steel stops are set up in a steel rack to suit the pole. Different color of light is shown where butts, edge-seams, frames, etc., occur, and the man on the levers is acting solely according to these colors.

The multiple punches have, as a rule, only three or four set-ups, that is to say, one set-up for butts, one for edge-laps, one for frames, one for, say, intercostal angles in conjunction with the edge-laps. In this case the watertight bulkheads could not be punched if the holes would not entirely coincide with one of the four set-ups. It is possible to omit a few holes in some of the set-ups, but this is done only by hand. The man on the punch can release any number of punches temporarily by disconnecting the gag-operating gear for these punch dies.

The Chester Shipbuilding Company, Ltd., has, wherever possible, carried out the idea of duplication and standardization, but very often has had to abandon it in the detail. The hull, engines, boilers, and, in fact, all large items for a group of ships have been duplicated.

The dimensions for all but two ships contracted for by the Chester Shipbuilding Company are:—Length, 401 feet; moulded breadth, 54 feet; moulded depth, 32 feet 9 inches. Some have had sheer, but, in the latest type, sheer is dispensed with and a raking forecastle and poop substituted, giving the effect of sheer, but simplifying the work of manufacture.

The results of the fabrication in the Bridge Company's mills as outlined above is beyond criticism. Work is fair, rivet holes require no reaming, and the resulting fit of joints and watertightness is excellent.

Constructing a ship becomes to a great extent a problem of routing, handling and erection of material and of riveting.

The Chester Shipbuilding Company, Ltd., and the Merchant Shipbuilding Corporation are now building some sixty-eight ships on the manufacturing principles outlined above. It is expected to embody even more than has been possible in the past the manufacturing idea, thus making it possible, in this day of labor shortage, to do a maximum of work with a minimum of skilled shipyard labor of the conventional kind.

DISCUSSION.

THE CHAIRMAN:—Gentlemen, you have heard the paper on "Fabricated Ships" which has just been read by the acting secretary. It is now open for discussion. This ought to be a very interesting subject, indeed. It is quite a departure from conventional lines, and it would seem that the shipbuilders present might have something to say, as to whether they believe it is a wise departure or not.

PROFESSOR HERBERT C. SADLER, *Member of Council:*—This is a very complete description of what is being done in a good many cases at the present time, but there is one point, I think, to which attention ought to be drawn. We may speed the manufacture of the various parts that go into steel structures, such as a ship, but, after all, there is the question of putting it together, and the riveting is certainly a very important part of this work. With the present shortage of trained riveters, I think that particular attention ought to be paid to this point.

What is wanted at the present time is, as a matter of fact, a ship more perfect, perhaps, than one ordinarily constructed, certainly not a ship thrown together. We have got to deliver cargo, and a lot of it, as quickly as possible on the other side of the Atlantic, and our vessels have to keep in that business as long as possible without repairs. If from any cause a vessel should get, say, leaky, and damage her cargo, she will be in rather a bad state when she gets on the other side, because that she may have to lay up for several weeks before she can go into a drydock to be repaired. The usefulness of that ship, therefore, is practically nil for that period of time, and the whole question, it seems to me, depends on the riveting so far as the hull is concerned, and the reliability of machinery, so far as that end is concerned.

The point I want to emphasize is at the present time we ought to build more superior ships, perhaps, than we do in the ordinary course of events.

ASSISTANT NAVAL CONSTRUCTOR A. W. CARMICHAEL, *Member:*—I might mention in connection with the subject of riveting that I was talking to one of the officers of a shipyard, and in speaking about this subject he said that in order for that yard to turn out their ships in the time the newspapers were saying they were going to be turned out, he would require one thousand gangs of riveters. This yard was then running full blast, and had only forty gangs of riveters.

MR. CLIFTON YEOMANS, *Member:*—It was with great interest and pleasure that I read Mr. Robinson's paper on "Fabricated Ships," as I have for years been trying to devise a system of quick construction for ship work, and have been for the last nine months especially interested in standardized steamships. The difference between fabricated steamships and standardized steamships is that in the latter case you are using your own multiple punch instead of making use of one elsewhere, and you plan your work accordingly.

The big handicap to quick ship construction is the riveting—it is a source of weakness, and for this reason we have to break joints, which makes for special work throughout the ship. The rivet hole is the cause of more trouble than any other thing in constructing steel ships.

We cannot have real standardized or fabricated steel ships until we adopt a stronger means of securing plates, a means whereby a greater proportion of the work is done before it gets to the ship's ways, and we must make this a system which will be more universal in its use. With this idea in mind, I have been engaged in devising a system of constructing ships of plates and round bars, similar to sheet piling, with caulking wedge to prevent working and to make watertight work.

I have patents pending on such a system, and submit my plan to the Society in connection with fabricated ship construction. (See Plate 30.) The weights of material would not be more than is at present required. With the cooperation of the mills the cost of construction could be reduced over 60 per cent, and the production of ships would be trebled. I think that my system has a special value in view of Professor Sadler's remarks about the difficulty of riveting ship construction.

THE CHAIRMAN:—Is there any further discussion on this paper? If not, we will extend the thanks of the Society to Mr. Robinson, whose absence we regret very much. Of course he is engaged in matters of great importance just now, and we can well understand how impossible it is for him to come to the meeting.

We will now go back to the regular order and take up Paper No. 11, entitled "The Influence of the War on Submarine Policy," by Mr. Marley F. Hay, a member of the Society.

MR. MARLEY F. HAY, *Member*:—I think I owe it to the Society to explain the circumstances under which this paper was written, that complete separation from my technical data by several thousand miles of salt water has compelled me to deal more in generalities on the submarine situation than in any specific technical information. Moreover, a certain amount of what we call discretion is supposed to be exercised, so that a paper of this kind has possibly its chief interest in what has been omitted rather than in what has been said.

During the reading of the paper Mr. Hay said:—

"About ten years ago submerging from the surface condition in twenty-five minutes was looked on as a rather creditable performance, but by the use of various means and devices that was reduced to a period of perhaps five minutes at the outbreak of the war, or four minutes with a skilled crew. I may say that at the present time a minute is looked upon as being a rather long time for getting completely out of sight, which shows that a very considerable advance has been made in that direction."

At another place:—"Incidentally I may mention that the high pitched sound of the motor of the gyroscopic compass is an element which leads to the detection of submarines"

THE INFLUENCE OF THE WAR ON SUBMARINE POLICY.

By Marley F. Hay, Esq., Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

The outbreak of war in August, 1914, found the supreme naval power, Great Britain, in possession of the numerically strongest submarine fleet. It comprised about 90 vessels ranging, with a few experimental exceptions, from 200 to 800 tons in displacement.

The submarine at that time was admittedly and manifestly the weapon of the weaker power, inasmuch as it was presumably a weapon preeminently of defense and it was hardly deemed politic for secondary or lesser powers to entertain aggressive national policies. Moreover, the tremendous pecuniary burdens involved in the acquisition and maintenance of a fleet of capital ships reduced this policy of defense to a policy of necessity. So conclusively is this the case that certain of the smaller powers have conceded the principle that, militarily speaking, submarines should form the major part of their fleet with only a certain number of destroyers and auxiliaries as supports.

During the nineteenth century, Great Britain has occupied the position of supreme naval power, hence all other powers have been comparatively and relatively in the position of navally weaker powers. The logical result of this status should have caused the British Admiralty to discourage early efforts to establish the practicability of the submarine, and that the situation was thus appreciated is evidenced by the fact that Robert Fulton, the American inventor of an early type of submarine, was offered substantial remuneration by the Admiralty for the entire suppression of his patents and ideas. This occurred a century ago after his failure to obtain recognition in America and France.

In 1914 Great Britain's numerical superiority in submarines was probably attributable to a belief in the suitability of submarines for coast and harbor defense, which had in fact been amply demonstrated by their success in the naval maneuvers of the preceding five years. The utilization of submarines for coast and harbor defense naturally released a certain part of their fleet for other and possibly more important work.

In a consideration of the effect of the war upon submarine policy, we are immediately concerned with the principal belligerents, and especially the central empires, whose sea policy has brought submarines into such prominence.

On the allied side, France entered the world conflict with a heterogeneous assemblage of submarines, about fifty in number, with the widest range of variation, both in regard to displacement and military characteristics.

The Russian submarine flotilla has played a very inconspicuous rôle in the operations that have taken place hitherto and can hardly be said to have influenced submarine policy, either technically or strategically. By and large, the same may be said of the other allied powers, and the comparatively late entrance of the United States as a belligerent, if nothing else, would account for the inactivity of American submarines as far as the major naval operations in the North Sea and in the waters surrounding the British Isles are concerned.

It may fairly be assumed, however, that since April last this country has profited at least potentially by the previous war experience of the western allies. Paradoxical as it may seem in the light of later developments, the last of the great powers to admit the desirability of or necessity for submarines was Germany, and that conclusion was only reached under the pressure of actual war, when it was manifest that the rest of her fleet was of practically no use. If one believes that the German government has been preparing for many years in anticipation of the present war, it seems incredible in view of the completeness of her preparedness in all other respects that the submarine arm of the naval service was neglected and discredited up to the day that war broke out. It was assuredly no oversight on the part of the German authorities, for in several conversations the writer had with Admiral von Tirpitz in 1911 in regard to Germany's submarine policy the latter expressed emphatically as his opinion that he considered submarines to be in an experimental stage, of doubtful utility, and that the German government was not at all convinced that they would form an essential or conspicuous part of their future naval programs. This opinion, which undoubtedly incorporated the opinion of his principal subordinates, was not expressed with any purpose of misleading, for it was a well-known fact at the time to every one in the profession that Germany's position in the matter of submarines was that of a third-class power.

When hostilities commenced Germany had twenty-five submarines in commission and was building perhaps half a dozen more. They were all of the Krupp-Germania type, and von Tirpitz explained almost apologetically that they had built a few just to be able to form some conclusions regarding them based on their own experience. It was evident at that time, however, that no great thought or attention was being devoted to their development, nor were ideas from outside sought.

Any casual student of European politics during the last fifteen years knows that in every international complication that arose and threatened European peace Germany was always to be found on one side and England on the other side as potential antagonists. If Germany had foreseen every contingency and provided for it in advance, she must necessarily have regarded the participation of England as an adversary in the present conflict, or, in fact, in any conflict in which Germany was involved, as a possibility at least, even if a remote one, and she must also have foreseen that the participation of England would bring about the enforced inactivity of the German high-sea fleet.

She could also have foreseen the situation that now prevails, *i. e.*, the submarine branch of her naval service would be the only one that could deliver any ef-

fective blows against England. Under these circumstances, how is it possible to explain the utter failure of the German government to comprehend, or, if they comprehend, to provide for the rôle that submarines are playing to-day? Is it possible the General Staff and the Reichs Marine-amt refused to recognize the possibility of England's participation as even a remote contingency, and that no appropriate preparation was made to meet it? It would almost seem so, for when England definitely entered into the conflict against Germany steps were taken in feverish haste to lay down over sixty submarines at once, and that number has since been largely augmented.

Estimates have appeared in print according to which Germany was credited with having over 700 submarines in her possession last May and that 1,200 would be in commission by the end of this year. It can hardly be possible that such an estimate has been made by any person familiar with the shipbuilding facilities of Germany, even making all due allowance for abnormal expansion of these facilities to meet the necessities of the occasion. It has been stated that drydocks would even be utilized for the purpose of erecting them, as if the problem were primarily one of ground space.

The entire shipbuilding capacity of Germany is very limited, compared with England, for instance, and the difficulty of finding highly trained and skilled shipbuilding labor such as is required for the intricate work of constructing a submarine would militate heavily against any sudden increase in the tonnage that could be turned out. Taking into account all the shipbuilding facilities of Germany, both private and governmental, making the most liberal allowance for the maximum extension of these facilities under pressure of war, bearing in mind at the same time the difficulty experienced in obtaining certain necessary machinery and appliances and in obtaining skilled labor, and deducting the number of submarines that have probably been lost or destroyed by the enemy, it does not seem possible that Germany had more than 200 submarines in commission last May. Of this number approximately two-thirds would be constantly available for duty, while the other one-third would be en route either to or from the various shore bases for the replenishment of supplies and for repairs.

To arrive at a fair or accurate estimate of the rate at which Germany can build submarines in the future is somewhat more difficult. Assuming, however, that all yards in the country were utilized exclusively for this kind of work and that no mercantile shipbuilding or repairs to the battle fleet were undertaken, which, of course, is far from being the case, the probability is that not more than 100 submarines could be completed every six months.

Information at hand would indicate that the actual recent output has been approximately 10 per month, of which the great majority are in the neighborhood of 800 tons to 1,000 tons displacement. Several groups of about 1,500 tons have also been commissioned and quite recently the construction of a flotilla of 8 so-called submarine cruisers of 2,800 tons displacement has been undertaken of which 3 or more are reported completed and the remainder will be ready for service by next

February. These vessels will mount two 6-inch guns, besides two guns of lighter caliber, and embody the innovation of an armored conning-tower. This is more or less essential where the conning-tower constitutes the central control station of the vessel and at the same time is the most vulnerable part. It is only feasible, however, on vessels of great size, because of submerged stability considerations.

All the later Austrian submarines have been manufactured in Fiume and Trieste from German plans and constitute, in effect, a German submarine flotilla in the Mediterranean that has avoided the necessity of the hazardous journey from the North Sea through the Straits of Gibraltar.

Turkey and Bulgaria have not been contributory factors in the submarine plan of campaign.

The effect of the war on the submarine policy of Germany has manifested itself in a tremendous program of acceleration and access of numerical strength with increase in displacement and radius of action, as hereinbefore indicated, to meet the exigencies of long cruises off the west coast of the British Isles, necessitated by the effectual closure of the English Channel.

It is not at all clear that before the war any of the allied powers, or for that matter the central powers, seriously anticipated or contemplated the possibility of ruthless submarine tactics against merchant shipping as at present employed by Germany. Nevertheless, some years before the war there was a lively discussion in the British press of certain alarmist literature, notably a book by Sir A. Conan Doyle, in which ruthless submarine warfare at its worst against merchant and passenger vessels was portrayed with grim accuracy. It was generally, if uncomfortably, dismissed as grotesquely fantastic with at the same time a secret hope that eventual enemies might fail to apprehend the pregnancy of the suggestion. The initiation of the sinking-on-sight policy was justified by its authors as another of those convenient "military necessities," the results of which would sanction its utilization.

That it was not a predetermined policy before the outbreak of war appears to be evidenced by the fact of Germany's complete unpreparedness at that time to conduct submarine warfare, coupled with the further fact that the design of the earlier German submarines indicated the intention of anti-warship rather than anti-merchantman tactics. Be that as it may, when the German submarine campaign was finally launched against the Allies in all its ferocity, academic questions regarding the presumptive policy of its inception had to give way to the physical fact of its reality and the necessity of counteracting it by every possible means. At a very early stage in the war, certain important areas were defended by a series of nets with various devices to indicate the presence of a submarine in the net and so aid in its capture or destruction. Large numbers of high-speed patrol launches mounting a 2-inch or 3-inch gun were employed to hunt and shoot down exposed conning-towers or hulls, and destroyers were rapidly fitted with emergency rams to permit them to charge submarines on sight with a fair chance of success without undue damage to themselves.

The immediate effect of these tactics on the part of the Allies produced the countermeasures of knife-edges and net cutters at the bow to facilitate penetration of the net, clearing lines and similar devices protecting all projecting parts to the same end, and housing periscopes to bring the top lenses in the housed position, below the clearing lines.

The larger submarines then under construction increased their armament to guns of 4-inch caliber to outrange the patrol boats, and the latest vessels with 6-inch guns are formidable opponents of a destroyer. The danger of ramming induced a radical increase in the length of the periscopes up to about 10 meters in some of the latest boats. By this means it is possible to keep a lookout in fairly rough weather with several feet of periscope exposed and at the same time maintain a sufficient depth of water above the vessel herself to practically preclude the possibility of successfully ramming. The conning-tower remains as the only vulnerable part in this condition, and the destruction of the tower, while serious enough, by no means entails the loss of the boat.

To reduce resistance to propulsion submerged and at the same time obtain sufficient rigidity in the free portion of periscope above the highest bearing, the use of these extremely long periscopes has necessitated an increase of the housing distance to the greatest practicable degree, the eye-piece in some cases being almost in the bottom of the boat when the periscope is fully housed.

The ubiquity of vigilant patrols and destroyers, frequently making no invidious distinctions between friend and foe, has necessitated on both sides a revised conception of quick transition from the surface condition to the submerged condition, whether statically or dynamically. The necessary sequence of operations to bring about this transition, which in time of peace were customarily performed consecutively, are now perforce executed simultaneously, and any practical expedient by which seconds may be saved is unhesitatingly adopted. Upon a given signal the engines are stopped, exhaust pipes closed, clutch to main shaft disengaged, conning-tower hatch closed, ventilators closed down, motors started, kingston valves and vents for flooding main ballast tanks opened and the crew all stand by at battle stations.

To still further expedite this maneuver the allied submarines navigate frequently with open kingstons, depending upon air pressure in the ballast tanks to regulate the ingress of water. The Germans, on the other hand, maintain a partial vacuum in the empty ballast tanks which in effect approximately doubles the head of water. As the tanks must, in the nature of the case, be filled while the vessel is still on the surface the head of water can never exceed the draught of the vessel, and even this comparatively low head is steadily reduced by the filling of the tank. With a given total area of kingston valves, the increased rapidity with which the water will flood a tank containing a partial vacuum instead of air at atmospheric pressure will be apparent. The usual vent pipes to permit the escape of air from the tanks are also fitted, and these are opened as soon as the vacuum gauge on the tanks indicates the re-establishment of atmospheric pressure. The partial

vacuum in the tanks is obtained by pumping out the air with the usual high-pressure air compressors that are installed for air service purposes.

The system is open to the objection that an emergency might arise demanding quick submergence shortly after a previous emergence and, before sufficient time has elapsed, to produce underpressure in the tanks. As the time required is comparatively short, however, and even a few inches of vacuum are effective in increasing the rapidity of flow, this disadvantage is relatively insignificant.

At an early stage it was apparent to the German authorities that the expenditure of 20-inch or 18-inch torpedoes on merchant ships represented wasted energy; moreover, the number of tubes and torpedoes of that size that a vessel could carry was relatively limited. At the same time, the general policy of defensively arming merchant ships militated against the German practice of coming to the surface and leisurely sinking the victim with a few inexpensive bombs placed on board or several well-directed shots from the gun, for which two to three hundred rounds of ammunition could be stowed.

These considerations, taken in conjunction, indicated the desirability of evolving a new type of small torpedo proportionate to the work to be done, of which a larger number could be carried on board than would be possible with 18-inch or 20-inch torpedoes within equal limitations of weight and space. This led to the adoption of the 14-inch torpedo and permitted the installation of approximately twice as many tubes and torpedoes in a given design.

The experience of the war has taught submarine officers to make the most of the virtue of invisibility; showing more than the top of a periscope during the twenty hours of daylight in the summer months is an undue risk not to be taken without sufficient reason. The energy of the battery must be conserved, however, to be available when needed in an emergency. To that end arrangements have been perfected to facilitate what is variously known as balancing, statical diving or suspending. With a minimum expenditure of power, the vessel remains stationary in the submerged condition with only the tops of the fully extended periscopes exposed. With the sensitive listening devices now extant it is of vital importance that this mechanism be as nearly noiseless as possible and that no air bubbles escape to betray the presence of the boat. By housing the periscopes during this maneuver, nothing is visible above the surface of the water.

It is sometimes employed when close pressed to elude pursuit when the depth of water is too great to permit descent to the bottom.

Another method of economizing battery energy frequently resorted to consists in navigating the vessel with the ballast tanks full and ready for diving under the Diesel engine. The only exposed portion in this condition is the conning-tower fairwater, and that is not a measure of the actual reserve buoyancy, for the apparent freeboard is due to the dynamic effect of propelling the vessel forward in this condition with the stern diving rudders set slightly to rise. The hatches all being closed, the air for the engine is supplied by a quick-closing ventilator.

This operation was regarded dubiously before the war, but its success has jus-

tified its wide adoption, so that what was once considered a precarious expedient has now become commonplace routine. Doubts were felt regarding the possible effect on the crew of a sudden inadvertent closure of the ventilator supplying air to the engines and a consequent rapid drop in internal pressure. In practice the effect on the crew is nil, other than a momentarily disagreeable numb sensation in the ear drums.

The use of nets in this war as a defense against submarines and the desirability of evading these entanglements by diving below them will probably lead in course of time, if it has not already done so, to the consideration of increasing the strength of the pressure hull to make submergence to a depth of 300 or 400 feet a practical possibility, instead of the working limit of 200 feet that generally obtains to-day. To accomplish this result a certain rather serious sacrifice of other military qualities will be, of course, inevitable.

During the first years of the war little success was experienced in combating submarines with submarines principally for the reason that their reciprocal invisibility militated against their finding each other except when one was on the surface. Later developments in submarine signalling and sound-detecting devices have made it possible, however, to hear a submarine even when it cannot be seen, and also to approximate its direction. That being the case, it is quite conceivable that a numerous flotilla of submarines submerged statically in suspected areas with only the periscope objective exposed might lie in wait until the sound of the enemy's propellers or the hum of the electric motors became audible. In all probability the sound of the propellers would be heard first and the comparatively high rotative speed should distinguish it from the propellers of an ordinary vessel. In any case a look through the periscope would resolve any doubt on the subject.

Proceeding in the direction whence the sound came, an effort would be made to locate the enemy's periscopes and get within torpedo range. Any submarines now in commission provided with the latest listening plates could perform the function of a submarine patrol with a certain degree of success, but it is evident that a submarine designed especially for this kind of work, in short a contra-submarine, would logically depart considerably from the characteristics of submarines proper as we now know them.

The evolution of a radically different type would involve for every nation the creation of a flotilla of contra-submarines to oppose the submarines the enemy would send against her. It is, of course, possible to make a compromise design combining the essential characteristics of the submarine-versus-warship type with the submarine-versus-submarine type, but such a compromise is not compatible with the highest requirements of either and is likely to entail the weak points of both and the preeminent advantages of neither.

For that reason two distinct and separate types are to be preferred.

The contra-submarine will do practically all of her work submerged. Therefore the displacement should be sufficient to ensure satisfactory habitability, and a very powerful battery and large motor should be installed to give the maximum

possible endurance submerged and the highest submerged speed at the maximum discharge rate of the battery.

On the other hand, battery efficiency expressed in output per pound of weight is highest when the individual cells are not too large, especially when the vertical measurement is at a minimum, nor is it desirable to unduly increase the voltage. Hence practical limitations are imposed which will possibly determine 500 to 600 tons as a satisfactory surface displacement.

Facility of maneuvering submerged also inhibits too great a displacement.

Everything that contributes to resistance submerged should be examined critically with a view to reduction or elimination. The conning-tower and periscope complex adds about 35 per cent to the total resistance, out of all proportion to its relative size. The periscopes naturally cannot be omitted, but a large reduction in resistance may be effected by restricting the function of the conning-tower to that of a simple entrance hatch to permit ingress and egress in heavy weather and reducing its section to the "irreducible minimum." If made of nonpressure-tight construction it could be of elliptical section and still further reduce its eddy-making propensities.

In certain French submarines built before the war the idea of reducing resistance submerged was carried to the extent of eliminating the conning-tower altogether and fitting in its place a canvas weathercloth to protect the entrance hatch in heavy weather. Thus the boat was virtually destitute of an entrance hatch that could be safely opened when seas were breaking continuously over the deck. After a few disagreeable experiences the practice was discontinued. There is no good reason, however, why the conning-tower or, properly speaking, the entrance hatch in this special case, should not be made housing to be elevated only when weather conditions require it.

Docking keels, bilge keels and other power-consuming hull appendages should be dispensed with, to the limit of absolute indispensability.

As for armament, the same process of logical reasoning that induced Germany to adopt 14-inch torpedoes would obtain in this case, although the writer believes that still smaller torpedoes, say of 12-inch diameter, would be preferable.

In stalking an enemy submarine, it is not likely that more than one opportunity to fire at point-blank range would be presented, and with the extremely long periscopes now in use there is no means of ascertaining whether the enemy whose periscope is sighted is 8 feet or 20 feet or more below the surface.

With housing periscopes adapted to be used in practically any position, the length of exposed portion of periscope no longer indicates the depth of the boat, so the possibility of a torpedo going over or under the target due to this uncertainty is considerable.

To reduce the influence of this disability to a minimum as many tubes as possible should be grouped for simultaneous firing, arranged at slightly divergent angles, with torpedoes set for various depths so that dispersed fire is obtained on the principle of a shot-gun.

Such a group of tubes can more readily be fitted in the bow than elsewhere. It is important, however, that the contra-submarine should have as great an arc of fire as possible with the minimum necessity for training the boat in azimuth, for which reason a battery of perhaps four stern tubes could be installed. Broadside tubes do not lend themselves readily to this arrangement, especially as each group could only be fired on one side. This consideration, together with the difficulty of firing from bow tubes at point-blank range in a vessel of large displacement, constitutes another argument against unduly increasing the displacement of these vessels.

They should, of course, be self-sustaining, therefore equipped with Diesel engines to charge the batteries in not over four hours. Therein lies their greatest vulnerability, although in that respect they are in a similar case with any other type of submarine. During the period of battery charging at night, they must not only come to the surface and sacrifice the immunity of invisibility, but the noise of the Diesel engine exhaust is distinctly audible for a long distance and characteristic in its quality. If the exhaust be arranged above the water line, it is directly audible. If an under-water exhaust be employed, the microphone of the listening plate on another vessel tells the story. From the two horns of that dilemma there appears to be no immediate escape, but it offers a promising field for ingenuity.

In stalking enemy submarines, either in the open or using a merchant ship as decoy, the element of chance naturally plays a conspicuous part. At least as much success will probably be attained when no decoy ship is used for the reason that the noise of the decoy's propellers will tend to obliterate the sound of the enemy's screws. An extensive zone of silence as complete as possible is really the desideratum, and all internal noise must be entirely eliminated. Under these conditions a sufficiently numerous fleet of submarine patrols in the theatre of operations would assuredly serve to cause the enemy some distraction other than the preoccupation of hunting down merchant ships, and this fact alone, not to mention its undoubted undermining effect on the enemy's morale, would justify its *raison d'etre.*

DISCUSSION.

The Chairman:—Gentlemen, this paper on "The Influence of the War on Submarine Policy" is a most interesting paper, and it is now open for general discussion.

Mr. Simon Lake, *Member*:—I have not any special comments to make on Mr. Hay's paper, except that I believe in Mr. Holland's statement made many years ago that you cannot fight submarines with submarines. I think an attempt to locate the German submarines by the use of other submarines would be very much like looking for the proverbial needle in a haystack. The chances of finding a submarine lying in wait off the entrances

to our ports are very slim. It is not necessary for a submarine to be under way; they simply lie in wait and the ships come to them. If the ships come within the submarine's range of sight, and the enemy has enough submarines in commission in that vicinity, that ship, in my judgment, is bound for Davy Jones's locker.

I wish to treat, Mr. Chairman, of the subject in a little different light, however. I may say, first, that the submarine is the answer to the submarine, but not in catching them. I believe that the only way to avoid the loss of our ships by the military submarine is to evade that military submarine. I have not prepared a paper. On my way to Bridgeport this morning I saw in the *New York Times* the statement that only one British ship of over 1,600 tons was lost last week and only a few neutral ships. As has occurred several times in the past, the newspapers are becoming enthusiastic over the fact that the day of the submarine is ended. Several times there has been a lull in the sinking of ships, to be followed in each instance by new tactics and an increased number of sinkings.

I had expected to see our own ports blockaded long before this. The submarine U-53 showed what was possible when she came over here one afternoon a little more than a year ago and sank six ships off the northern entrance of Long Island Sound, and I had wondered why the Germans had not done so before. I think the answer to that is because of a desire on the part of the commercial people in Germany not to make enemies of the people in this country, to avoid creating animosities which will not die out for generations. They want to continue to send us their goods. That, I believe, is the real answer to their not sending their submarines over here up to date.

Now, I fear, the withdrawal of these submarines from the high sea is to put them in shape to come over here. I hope not, but they have already proven it is possible.

Just before this war came on—just before America entered the war—I spent several thousand dollars personally in advertising, sent advertisements all over this country, purely for the purpose of calling attention to the possible danger to us if we got into the war without being prepared to safely carry supplies to our allies, because we were not prepared, and now that we are in the war we must send supplies in large quantities and must continue to do it, especially as our boys are going over there.

I believe it is possible for submarines to stop commerce in surface ships on the high seas, and when I read the paper this morning on my way to Bridgeport—I had forgotten that this meeting was to be held to-day—and saw the reference in the paper to the meeting of this Society, I got the next train back, feeling that I should come here this afternoon, that it was a patriotic duty to come here and tell this organization of shipbuilders and marine engineers some things that have not been made public before, in regard to what I believe the Germans are capable of doing. I lived in Germany and Russia for several years, and I think I know their general characteristics. Now, because of my fears of the possibilities of the German submarines cutting off our commerce I published the statement to which I have referred, and was called all sorts of things for doing so, pacifist, etc., but I also received some letters of commendation as a patriotic citizen in trying to have the country prepare for the interruption of our overseas commerce and that I was doing the proper thing to point out the possible dangers to this and other neutral countries by our becoming entangled in the war. I also received one letter from a New York hotel, unsigned, which was the shortest one of the lot. It said:—"After reading your advertisement, I have come to the conclusion you are a damned fool." So you gentlemen can take your choice after hearing what I have to say.

I am willing to admit I was a pacifist before the war in trying to keep this country out

of war. My natural tendencies are pacifist, but I am not a pacifist of the kind that if somebody hits me on the left cheek I am going to turn around my right cheek to them, and let them hit that. As I said before, I have lived in Germany, and I left Germany because I could not stand certain of their characteristics, and the fact that those characteristics have been extended to this country makes me fear for this country and our allies. I do not deny that I am very fearful of what is likely to happen.

THE CHAIRMAN:—I dislike very much to interrupt the speaker, but I ask him to please speak of the submarine, and tell us something about that, because we have some other long papers here which we must have read and discussed this afternoon. We would like to hear all that Mr. Lake has to say, and if we had the time we would give him the whole afternoon.

MR. LAKE:—I got very much interested in this subject coming in on the train this morning. Perhaps I have wandered a little away from the main point of the submarine. I will try to come to the point I want to bring before you. I stated that I expected to see German submarines on our coast. I appeared before the Navy Department several months ago and submitted at that time plans for a type of boat which I thought would evade the military submarine. Captain Land, I believe, was one of those who saw the plans at that time, and he said it was not up to the Navy Department to build merchant submarine ships, that I had better go to the Shipping Board and see them. I did. I took my plans over to the Shipping Board and saw Mr. Denman and General Goethals, and a committee was appointed to investigate the merits of the type of vessel I proposed. We had two or three meetings together, and they all expressed themselves as believing that the type of boat I submitted might solve the problem, and at the request of Mr. Denman I investigated the possibility of getting them built quickly, visited different mills in Pennsylvania, and submitted the proposition, at his request, for one hundred boats. But somehow differences in the Shipping Board arose, a new board was appointed and nothing has come from it. Since then a member of the British Commission came over here to visit me, and I have had requests to build these boats for British shipping companies. I was obliged to reply that it was impossible to construct boats in this country without the approval of the U. S. Government and its cooperation.

Now I believe the only thing that will avoid the military submarine is to evade it, not by counter submarines of the type which Mr. Hay described to search for the military submarine, but by cargo-carrying submarines. We all know that the Deutschland came over here and made four successful trips, passing the English patrol of cutters and vessels that were looking for her both on the other side of the Atlantic and also on this side of the Atlantic, yet she successfully evaded them. I met Captain Koenig on his arrival here and had several discussions with him as to the possibility of constructing similar submarines on a larger scale; in fact, at that time I was asked to build for the North German Lloyd Steamship Company submarine cargo carriers in this country. As we were neutral at that time, it was entirely proper to go into that phase of the subject, and, based on Captain Koenig's experience, combined with my own, I believe it is possible to build cargo-carrying submarines at very little additional expense over that involved in building the ordinary oil carrying merchant ship, and to build them rapidly—submarines capable of carrying up to 10,000 tons, if you wish. I had boats at that time designed for 5,000 tons, and since then I have had designs worked up for boats carrying 7,500 tons, whose weight of hull and machinery does not much exceed the weight of hull and machinery in an oil tanker of equal carrying capacity.

I had no idea, when I started to speak, of explaining these points, but I feel that under the present condition of things the more we know of the possibilities of the cargo-carrying submarine the better it is for this country, our allies and our boys who have to rely on the products of this country to prevent them from starving.

Captain Koenig told me that in his trip accross the ocean he saw numerous vessels, but they did not see him, and that it was not necessary for him to submerge after he left the North Sea. He did submerge every day, just merely to keep his crew and boat in trim, but was able to avoid all the ships which he saw, due to the fact that his vessel was so low in the water. He kept lookouts at the top of his wireless masts, and he could see the large upper works of a vessel long before it could see him. Usually smoke was the first thing that indicated the presence of a ship, and he made it his business to steer away from smoke, because he knew it could not be a friendly vessel.

You can see how that could be the case. Take the military submarine, submerged; after she comes above the surface she is just as likely to be discovered as any small service vessel would be. There would not, however, be the same likelihood of discovery as in the case of a great big ship, like the Lusitania, with her great smokestacks, and smoke showing well above the horizon. Now that is the real reason why the little military submarine has the advantage, and I have worked up some plans which show the comparative danger area of the two types. Of course the submarine, with its periscope extended, say 15 feet, cannot see far over the horizon, for at that elevation the horizon appears 5⅛ miles away, and consequently the lookout on the submarine cannot see a man in a rowboat, for instance, as he would appear below the horizon. If you had another submarine, or a low visibility ship, with say 15 feet freeboard and no smoke appearing above the ship, the range of visibility would be about 10¼ miles; but take a ship like the Lusitania, or the type we are now building, in such a case the range of visibility would be greatly increased—the range of visibility of the Lusitania from a submarine lying in wait was about 18⅜ miles at the top of her smokestacks. The smoke may extend into the heavens some 200 feet and thus show the approach of the vessel. The type of vessel we are building, and I am building some, I am glad to say——

THE CHAIRMAN:—I would like to know how much more time Mr. Lake desires. To be perfectly frank and brutal, we do not usually give over ten minutes to a speaker, but in the case of a celebrity like Mr. Lake, we will extend the time. Please get to the point and tell us what you want to say.

MR. LAKE:—The point I wish to make is—the less portion of a vessel that appears above the horizon, the less chance there is for such a vessel to be discovered. If you get down below the surface you cannot be seen at all. It should not take so long to explain this obvious fact, but the type of boat suitable for the purpose is the main thing. I regret I have not sufficient time to explain how simple such a vessel is. What I was going to propose is that a committee of this Society be appointed to investigate the merits of different types of boats capable of avoiding submarines. That is what I was leading up to—I do not want to miss this point.

THE CHAIRMAN:—Does any one else want to speak on Mr. Hay's paper?

NAVAL CONSTRUCTOR E. S. LAND, *Member*:—I would like to say one thing in connection with Mr. Hay's paper, and one thing in connection with a remark made by Mr. Lake.

In regard to Mr. Hay's paper, I think he underestimates the preparations made by Germany for this war as far as submarines are concerned. I think undoubtedly more than twenty-five submarines were available. Statistics will show that between thirty and thirty-six were available. They were also building in Germany quite a number of submarines for foreign countries which were commandeered at the outbreak of the war. The submarine knowledge in Germany was as great, if not greater, than in any other country in the world at the time that the war broke out.

I state this merely to show that they have not evolved any world wide superhuman ability in constructing remarkable submarines, but what actually happened was that they absorbed the brains and genius and plans and patents of every country in the world they wanted to. They had done little or nothing up to 1904 or 1905, and bided their time from then on until they got what they thought were the best features, and they were then prepared to go right ahead and do the work on the submarine.

I agree with Mr. Hay and definitely stated in my paper that the submarine is the best antidote for the submarine. Mother Nature never made two like things but that they could fight each other. Two seedlings fight each other to get the greater share of sunlight. Two dogs will fight each other. Two children will fight each other. Two submarines can fight each other and fight until one is sunk. If you have a home, and it is entered by two thieves, the chances are the thieves will see each other before you see either one. The saying that "it takes a thief to catch a thief" is logical and has been proven by experience over and over again. I do not agree with the statement of Mr. Lake that the submarine cannot fight the submarine. The submarine can fight the submarine, just as well as the destroyer can fight the destroyer, or a battleship can fight another battleship, and there is no physical reason why it cannot do it.

The submarine operates on what is called "hunting grounds." All right, there is no reason why another one cannot operate in the same way, but for a different purpose. If you are going on a duck hunt and there are ducks 5 miles away and 100 miles away, the chances are you will go to the 5-mile point; that may have something to do with the lack of more U-53's over here.

Naval Constructor T. G. Roberts, *Member:*—Last year there was a very interesting paper by Admiral Rodgers entitled, "On the Suitability of Current Designs of Submarines to the Needs of the U. S. Navy." It was contended by some that the type we then had in existence, on account of its facility for more rapid reproduction, was entirely suitable. The question of expediency, of what is best to do, whether to have a larger number of submarines that we can secure quickly, or build submarines of larger sizes at a slower rate, is an important one. My colleague, Commander Land, who has just been talking, believes in the larger size, the 800-ton submarine. Of course our Navy Department, like the average American in every-day life, always like to go the other fellow one better, and always goes to the bigger sizes. It was a moot question, and is likely to remain so for some time. The information we have upon current features of design abroad is comparatively meager. All the avenues of information are closed down pretty tight, and I think it is largely a matter of conjecture what we hear on the subject. When we reach a conclusion, it will be due to information that will be more accessible after the war than it is at the present time.

The Chairman:—Are there any further remarks? If not, Mr. Hay will have an opportunity to make any rejoinder he cares to.

Mr. Hay:—In regard to Commander Land's opinion as to the number of submarines Germany possessed at the outbreak of the war, I was not endeavoring to be precise, but simply to indicate that Germany up to that time had looked on the submarine program very skeptically. According to the statement of Von Tirpitz, who was reputed to be responsible for the great extension of submarines upon the outbreak of the war, he did that much against his will, and simply under the circumstances of a compelling necessity. The actual number of submarines Germany had in commission at that time was probably more than twenty-five, but at all events it was a very small number compared to her naval strength in other directions.

There is one point I would like to make in regard to cargo-carrying submarines. I do not think that is any answer to the submarine menace whatsoever. I think that if enemy submarines cannot be dealt with as such, that it is not sufficient reply to that menace to construct a huge number of cargo vessels and simply multiply the number of targets. It naturally alleviates or mitigates the situation, to some extent, but it is certainly not a sufficient reply.

The cargo-carrying submarine, from the point of view of efficiency, is about the most hopeless proposition that could possibly be considered for that purpose. The Deutschland, for instance, was able to carry approximately 20 per cent of her total displacement in the form of cargo, and she was carrying 80 per cent in the form of her own weight, which means, except for the purpose of carrying diplomatic messages, gold, and a few other precious substances, it would hardly be a feasible plan for keeping up communication, we will say, to supply an army. Then, again, there is another consideration which, to my mind, makes them entirely unsuitable for the purpose, and that is, not only the small amount of cargo they can carry, but they would not enjoy a very much greater degree of immunity from submarine attack than the ordinary surface vessel, for this reason—in the cargo-carrying submarine as much as possible of the available weight has to be given over to cargo, which means at best not more than 20 or 25 per cent of the total displacement, and the rest of the weight must be put into the ship herself and batteries for running submerged. Even so, in the case of the Deutschland, she was able to run submerged only about 5 miles per hour, and running submerged for thirty hours she only accomplished 150 miles. If the Deutschland attempted to navigate the Atlantic under those conditions, if that became the general practice, then it would be necessary for enemy submarines to hunt out and sink such cargo-carrying submarines in exactly the same way as they now sink ships, so that the only immunity from attack these cargo-carrying submarines would enjoy would be when submerged at a speed of 5 miles per hour, with intervals on the surface so that they can recharge the batteries, which is not a very practical way of getting across the Atlantic. It was conceivable that the Deutschland would be able to make a few isolated trips, because at that time the Allies were not maintaining a very effective patrol beyond points in the vicinity of the British Isles, we will say, but if it became a regular practice for huge fleets of cargo-carrying submersibles to cross the Atlantic from here to Liverpool and to the other ports of the British Isles and to France, it would be possible for the enemy submarines to lie in wait for the cargo-carrying submarines, and if they appeared on the surface, to hunt them down and attack them in precisely the same way as the ordinary merchant vessel is attacked.

The Chairman:—I am sure you will all desire me to convey the thanks of the Society to Mr. Hay for his splendid paper and for his concluding remarks. The whole discussion, everything, has been most interesting in every way.

The next paper to be considered is No. 12, entitled, "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, Member. You must not be frightened by the size of this paper, which consists of more than one hundred pages of text, because Constructor Roberts, the author, is not going to read the entire paper. What he expects is that you will all take opportunity, as time offers, to read the paper carefully. He has prepared it with great care, and will read but a brief extract of it, and then afterwards there are a number of eminent authoritities on this subject of industrial management here who are going to discuss the paper. I have pleasure in introducing Captain Roberts.

Naval Constructor Roberts then presented the paper.

AN ANALYSIS OF THE PRINCIPLES OF INDUSTRIAL MANAGEMENT.

By Naval Constructor T. G. Roberts, U. S. Navy, Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

INTRODUCTORY.

It would seem that an introductory explanation is due at the start in order to account for the presentation of this paper, as well as to outline what may be expected in the following lines. The writer's particular interest was aroused by the campaign of education upon the subject called "Scientific Management," which was extended into that branch of the naval service of which his own line of work is a part, and which affected the question of organization and management at the navy yards; and it was in order to analyze and evaluate the new style of management that this investigation was undertaken so as to be in position to influence the results as far as possible and as the merits of the case would seem to require.

A conclusion was reached about the beginning of 1913, and it was favorable to many of the claims presented, though unfavorable to others, and on the whole adverse to the suitability of the Taylor system for application in the navy yards; and such conclusion was communicated and it is hoped utilized advantageously in that connection. Since that time a number of circumstances have arisen to incline the writer to prepare a paper upon the subject. In 1912, while pursuing the investigation, Mr. Frederick W. Taylor suggested to the writer to prepare such a paper and, subsequently, a number of people with whom the subject has been discussed, including men who were being called upon to cast their vote upon the bills that were then being presented upon the question, as well as men in technical lines of work, have requested a written statement embodying a full explanation of the matters of management in discussion and dispute.

During the interim between then and now, it has seemed that the flood of literature appearing in the magazines and technical press was quite sufficient for all purposes and that the subject had already been so well advertised that an additional paper might hardly be worth while, when placed in current competition with so many conflicting claims, in view of the general confusion of the subject of a few years ago. In fact, it seemed there was too much such literature, especially of that brand which conveyed glittering and confusing generalities, and that the general public were already tired of the matter.

It is hoped that now, after the storm has subsided, this may be a suitable opportunity to present the discussion in a more impersonal and disinterested light. Therefore, pursuant to a request on the part of your secretary two or three years

ago to write a paper upon the subject of "Shipyard Management," which request, owing to delays, was repeated last year, the subject being then named "Shop Management," the writer has at last, after having assembled the subject-matter under what it first seemed best to name a review of the principles of industrial management, has finally completed it, and somewhat hesitatingly named it an "Analysis." It has been found desirable to outline in the first chapter a description of the Taylor system, and the effort has been made to present it in a descriptive way by dealing only with the essential principles as derived from the underlying reasons; it is hoped that tentative readers may not be deterred by the belief that it is merely a repetition of the highly technical and elaborate descriptions of that system as undertaken by Mr. Taylor and his various associates.

In order to establish a basic foundation for the subsequent chapters, it has seemed particularly desirable to begin at the source and travel with the current down stream, so to speak, throughout the labyrinth of principles and mechanisms that go to make up the science of industrial management as a whole. In referring to various elements of the Taylor system, it has seemed desirable to include upon the accompanying charts the various slide rules, tools, etc., of Mr. Taylor and Mr. Barth, and such reference has been made that the reader may locate the literature describing the details of the same; for the purposes of this paper, however, it has been deemed sufficient merely to present them in evidence and to indicate their nature and purposes in a general way.

The endeavor has been made to make the reading matter as easy and attractive as possible, in order to lead non-technical readers over into the chapters upon "Time Study" and "Premium." In the last-mentioned subject it has seemed desirable to make a scant reference by definition to the various payment systems, in order to render the subject complete, but that, too, has been dealt with in such a way, it is hoped, as to make easy reading for the sake of getting it out of the way for suitable entry into the subject of "Psychology of Management," which the writer believes is probably novel to a certain extent, and somewhat different from what may be found assembled elsewhere as applied to management.

The chapter upon "Political Economy in Management" is aimed to be perhaps more elaborate and compact than is usual to find assembled in connection with this subject. It would not seem a complete paper without bringing out the wonderful findings of Mr. Taylor as set forth in his book upon "The Art of Cutting Metals," which is condensed and presented in a form aimed to be interesting and informing. An evaluation of the "Emerson system" and the "Vickers system" has been attempted in passing, as there are no other systems, as such, which seem sufficiently well known or definite to deserve attention in this connection.

The chapters on "Organization" and "Cost Accounting" are essential and could not be omitted. The chapter on "Welfare Work" was originally intended to be the last, and is altogether one of the most important, and it is hoped the attention may not lag until that point be reached by the reader, even if some of the intervening technical matter should have to be scanned more lightly. The

human element is by far the most important factor in peace, in war, in industrial management, and in every line of endeavor in which humanity is interested. In order to terminate the paper suitably, in its application to the point of interest of the Society of Naval Architects and Marine Engineers, it has seemed fitting to conclude with the chapter upon "The Shipyard of To-day," under which the endeavor has been made to sum up the foregoing matter wherever particularly applicable in the embodiment of industrial management as affecting modern shipbuilding.

THE TAYLOR SYSTEM.

It is fully realized that Mr. Taylor has contributed far more to the development of the art of industrial management than any other man, but, more than that, he published to the understanding of the world not only those elements of management developed by himself, which were comparatively few in number, but also a summation of all those elements, not originated, but only assembled and applied by him together with his own, that formed the particular combination of elements which is, and should be, known as the Taylor system. Mr. Taylor did not agree with the writer in this particular but insisted that "Scientific Management" was the proper designation. Whether that was due to modesty in refraining from attaching his own name to it, or to a desire to aggrandize its title by throwing over it a mantle suggesting omniscience, the writer cannot say. Certain it is that many took exception to the last-mentioned title, and rightfully so, since such designation, applied solely to the Taylor system, had the effect of denying, by implication, the attribute of "scientific" to all other systems, of which there were a number. Furthermore, management is an art and not a science; and so, to settle the matter, the American Society of Mechanical Engineers appointed a committee, some years ago while the subject was at fever heat, to select a more suitable name; and that committee, after formal sittings, announced that the correct title should be, "Labor-Saving Management." Such name, however, did not stick for the obvious reason that it did not fit. Such a designation was understandable, however, coming as it did from ardent advocates of the Taylor system, but was defective in that its terms begged the very question which was widely disputed and which remained to be proved. It was not subject to the implied analogy, evidently entertained in the minds of the committee, with "Labor-Saving Machinery," about which latter none could set up a denial.

The Taylor system may be likened to a hydroplane, whose component parts, such as gas-engine, propeller, wings, float, wheels, etc., are not new in principle, but have been used previously in different combinations on other craft. But the particular combination as used on a hydroplane, together with certain new elements added by the inventor, embodies a new and distinct invention; and such, in management, is the Taylor system—correctly so named and described. Mr. Taylor assembled and used well-established and well-recognized elements and principles of management from various sources embodying the best developments of modern

industrial management in America, aside from his personal contributions to them, and has forever associated his name with all of them by being the first to publish a full explanation of the principles of good management for the edification of all sorts and conditions of managers—in fact, intimate methods, trade secrets and matters held as confidential between managers, that were esteemed as valuable assets to manufacturers and not subject to be communicated to rivals and competitors. As America was named after the man who drew the map and not after the discoverer, so the readers of Mr. Taylor's works will hereafter attribute to him many elements comprised in his system which did not originate with him.

Mr. Oberlin Smith, in his discussion of Mr. Taylor's paper before the American Society of Mechanical Engineers, said:—

"I want to congratulate the Society and the writers of these three papers upon the splendid work they have given us, and especially Mr. Taylor, because his paper is more comprehensive than the others. One fine point about it is that it is not his only. He has taken in all that is good that he could get from anywhere, and I believe the Society is doing a good work in disseminating such facts and records as are contained in papers of this sort."

Mr. H. Emerson, in his discussion at the same occasion, said:—

"Mr. Taylor's achievement is that he is the first one to use perfected scientific methods, one of them a microscopic study of Time Units, to get at the elemental cost of all production."

Mr. Taylor, in the discussion, said:—

"So far as I know, I was the first to introduce a system of management containing the following elements:—

"1. A careful study of the time required to do the work.

"2. Detailing instructions to the men, telling them how to do their work.

"3. The thorough standardization of all details which affect the speed of the work.

"4. The payment of a premium for success accompanied by a corresponding loss in case of failure."

These four elements outline the motive principles of the Taylor system and it is seen that Nos. 2 and 3 relate to No. 1, since the purpose of instruction cards and standard conditions is to permit the time of an operation to be reduced to a minimum. No. 4, the premium, and No. 1, the time study, are the essence of the system. Out of the time study came the task to be set for each job, the allotted time on which the premium was based being the least time in which it could be done by a first-class workman. Of the importance of these two leading elements, Mr. Taylor, in his paper, referring to the details of his system, said, * * *

"And first among these comes the study of 'unit times.' This, as already explained, is the most important element of the system advocated by the writer. Without it the definite, clear-cut directions given to the foreman and the assigning of a full, yet just daily task, with its premium for success, would be impossible; and the arch without the keystone would fall to the ground." Thus, premium is the arch and time study the keystone of the Taylor system.

It may be mentioned here in passing that the revelation contained in this quotation was like Samson confiding the secret of his strength to Delilah, as it affected the labor organizations, and these organizations aimed straight at the heart of this system when they engineered the project resulting in the congressional investigation at the hearings of 1912. The committee, over the signatures of Messrs. W. B. Wilson (now Secretary of Labor), Wm. C. Redfield (now Secretary of Commerce), and John Q. Tilson, reported to Congress that standardizing and systematizing of machines and work in the shop should be encouraged; but that stop-watch time study should not be made of workmen without their consent, and that bonus and premium work should not be introduced except by mutual consent. Recent laws for the Army and the Navy forbid both time study and premium; so the Taylor system, as a system, is a dead letter at present for government application. Such was the verdict of organized labor.

The third element of the Taylor system, standardized conditions, contained so much of value growing out of Mr. Taylor's own experiments as well as his comprehensive descriptions of them, and out of the work of his numerous assistants and collaborators, that it seems this element alone is worthy of being classed as the major part of scientific management, estimating the latter as a whole, of which the Taylor system itself is but a portion. All shops have no doubt aimed at standard conditions, but in two leading particulars of this connection Mr. Taylor's experiments introduced features new in their application and monumental in their consequences, viz.: (1) The Art of Cutting Metals, and (2) Functional Foremanship.

THE TOOL.

Mr. Taylor sought the tool which would remove the greatest amount of material in the least time and at the least cost, and his experiments led to the invention of high-speed tool steel which did the work quicker than any other. To get the most out of this steel he found that the tool should not be run over one and a half hours, and then should be replaced and reground, that certain shapes of tools were best for continuous cutting and regrinding, and he invented a standard tool grinder in two sizes which may now be bought upon the market. He found that in order to supply these tools and replace them on the machines in the shop, as needed to permit all the machines to run uninterruptedly, it was necessary to have an adequate tool room, called the heart of the shop, and a separate tool-grinding force.

The idea was to keep the machine operator and his machine busy cutting materials at the maximum rate without interruption during the working day, and the operator could not thus stop to grind his own tools as in former times. The tool

room had ample racks for storing tools numbered by a mnemonic symbol system for quick location and identification, "mnemonic" meaning a letter or combination of letters forming an abbreviation that suggests the name of the tool. There was made a complete inventory of all tools in the tool room, listed by mnemonic symbols. A careful study of the needs of the shop determined an adequate supply of tools, and the rate and numbers required for regrinding. No operator was to leave his machine to go to the tool room, but the tool was sent to him by his boss or by messenger. Every tool was charged out by check and the operator held responsible therefor for other than fair wear and tear. A tool broken or lost through carelessness was charged to him and noted on his record.

What a source of reform was this knowledge for all kinds of shops all over the country, including navy yards and private shipyards alike! How many rats' nests were cleared out from under the benches of workshops where tools were formerly scattered around indiscriminately! How much time was saved by operatives who had been in the habit of fetching and grinding their own tools! Thus science and order were introduced in the tool room, and this was found necessary as the result of experiments made with a view to supplying the man at the machine with a positive and continuous tool service, one that would be certain not to fail at any time but remain completely subservient to the purpose in hand. The point demanding constant service was the point of the tool. Herein lay the measure of the cost of the work. For removing the greatest quantity of metal in the least possible time, the quality of the cutting tool itself having been developed to the very maximum degree, and the shape of the tool having been determined for maximum economy of service and of regrinding, the problem arose as to what speed, feed and depth of cut were best to adopt in order to secure the maximum results while maintaining a good job, and so as not to injure the material cut or the cutting tool beyond the limits set for the finished surface, thickness of chip, chatter of tool, cooling of lubricant, etc.

This problem had twelve variables, with more unknown quantities than equations, and was solved by Mr. Carl Barth. The results were transferred by him into a slide-rule from which, for a given diameter of work, the three variables are determined—speed, feed, and depth of cut. Every different job requires its own solution of this problem, and the slide-rule must be consulted each time except on repeat work where the results become known by heart. Every different class of machines must have a slide-rule of its own.

THE MACHINE.

The next problem was to set the machine carrying the tool so that it would drive the tool at the desired speed, feed, and depth of cut. The machine's own gearing provided for two of these desiderata, but the speed of the cutting tool is dependent upon the pulleys, or cone, back gearing and gears, and it was necessary to figure out this speed for each combination of gears, back gearing and pulleys, and tabulate them and post the table for ready reference at the machine. This enables the machine to be set quickly and accurately.

Mr. Barth made a slide-rule to solve this problem also, and in 1908-1909 used such a slide-rule for a machine shop in the New York navy yard under the general supervision of the writer, and made and posted tables for every machine. That work now seems ludicrous, being such a small part of the whole problem, for of what use was it to know how to set a machine so as to get a desired speed, feed and depth of cut when one did not have the balance of the paraphernalia to know what speed, feed and depth of cut to take for a job of work?

It would be quite useless to explain how such a partial application of standardizing shop conditions came about, and would make another chapter upon the futility of government ways and means; suffice it to say that the machines were old machines, installed before high-speed tool steel was heard of, and were designed for slow speeds and smaller loads. Mr. Barth strengthened them and speeded them up so as to take the new loads and speeds, to which he then applied his slide-rule and tabulated the results for guidance to obtain a given speed. That was little enough, but it was more than the writer had been a party to at the Mare Island navy yard in 1903 when high-speed steel first made its appearance there.

As acting head of the Department of Construction and Repair during an interim of six months, the writer witnessed the results of a demonstration of the superior cutting qualities of the Novo brand of high-speed tool steel, and immediately bought on requisition an ample stock of same; but the obstacles in the way of speeding up the machines and otherwise reforming the whole work were greater than were even thought of by him, although the speeding up of machines was then being discussed in the technical papers, and the necessity of it was easily foreseen. The gap between then and now is immense in point of time, but not so great in point of progress in the art of metal cutting under the government purview. New machines, designed since the advent of high-speed steel, of course took care of the increased speeds and loads, but the great bulk of the machinery in the plants of yesterday and to-day were installed in an earlier day.

How many manufacturing plants, navy yards and shipyards have neglected to speed up their old machines? How many have failed to analyze their machines and find out whether they can attain with them the high speeds necessary to take advantage of the benefits of the expensive high-speed tool steel with which they have filled their shops? How many have even read the wonderful book of Mr. Taylor, "On the Art of Cutting Metals," which alone would render his fame everlastingly secure?

Let each one answer for himself these questions. Those who have not done these things have been groping in the dark; they have been expending vast sums upon production through the point of the tool without guide or compass save for the general direction and momentum of past practice as summed up in the experience of the workmen and shop foremen.

Therein lies the potentiality of a vast difference between scientific results imposed by the management and ordinary judgment imposed by the workmen. The very definition given of scientific management in its most accurate application lies

in this point—the substitution of accurate knowledge derived through science for the old-time guesswork. Whoever deals with shop management cannot afford to lose sight of the fact that the point of the tool is the queen bee of the shop, entitled to precedence over all, and to whom all other considerations must bow, for the sake of the life, the spirit and the economy of the hive. In building up the service around the tool, the machine and the man united and conspired together upon the tool. The machine was speeded up to reach the limit of the tool, and the man was speeded up by time study and premium to reach the limit of the machine; so that both man and machine cooperated to maintain the tool in the act of cutting metal at the maximum rate constantly between clock-strike and clock-strike. The machine, therefore, in order to be always in certain condition to meet this program, must be examined regularly and systematically and repaired out of regular hours or replaced temporarily by a relay machine.

Hence, in a large shop, the development of a regular force of repair men, in addition to the machine operative, under a repair boss, who performed no other function, and there you have one of Mr. Taylor's functional foremen. In order to maintain the machines at their proper speed, in a large shop with a number of machines, it was found necessary for a man to devote his whole time to this function alone; and hence the derivation of another functional foreman, the speed boss, a man trained in the art of cutting metals.

The subject of the machine is not complete without mentioning its auxiliaries, accessories and parts, of which each machine should have a full supply determined by a careful analysis of the work of the shop. All jigs, templates, fixtures, clamps, bolts and other attachments should be listed and stored, preferably in the tool room for crowded shops, or in some special place more suitable.

Rarely, such fittings have been stored in special boxes installed at or near the machine, with an inventory list pasted inside the door of the box. This can be done where space is ample. Tote boxes are sometimes used to advantage to carry such parts, and the regular tool supply and other odd articles of materials for the service of the machine. Messengers, push buttons, and cash-box trolleys were among the frills of this system, for the service of the machine, and these are now among the subjects of ridicule in such plants as the Bethlehem Steel Company, where they were once installed and have been subsequently discarded.

THE BELT.

In order to run the machine continuously at maximum efficiency the belts not only must not break or slide off, but they must also have the proper tension in order to have the minimum slip and transmit the maximum power without damage to the belting and its attachments. Belts must be treated and cared for so as to maintain their normal lives and be always in working order during work hours and subservient to the point of the tool. Hence they must be tightened, readjusted and renewed by the repair boss outside of regular hours.

There are so many considerations affecting leather belting that a veritable

little sub-branch of scientific management has grown up around that subject. From the literature one would think that economy in the use of belting was the main objective, which it is not. That consideration is merely incidental and minor, and has been stressed probably because savings can be illustrated in concrete figures. The main purpose of this solicitude about belting is to serve the higher uses of keeping the machines constantly in service.

The economy of the shop is outraged by a tool stopped, and a machine and a man standing idle, with all the accruing overhead charges running, for an hour or two while a broken belt is being mended by an improvised force of belt-repairers; to say nothing of such cases as slack belts driving under-sped machines at reduced rates of tool speeds in shops where the science of the belt is not understood.

THE MAN.

Assuming the man to be speeded up at those junctures where his efforts are exerted towards keeping the machine operating continuously, it was necessary to keep this man at his post and to build around him a system of service so as to supply him with tools, jigs, fixtures, etc., as already described, with drawings, and also with jobs, materials, oils and running supplies, and instructions, so that each job might dovetail into the one before it and the one after it, without loss of time at each juncture.

It was found that, to properly serve a group of machine operators in the above particulars, it required a gang boss who should perform such function exclusively, and hence another functional foreman. He directs the efforts of the men to the above ends up to the time the work is set in the machine, when the speed boss takes charge of the man and the work. At the shop work board, which is sometimes duplicated on a small board with three pockets at the machine, there are three job cards for each machine, one of a job in the machine, one of a job with materials and accessories assembled ready to begin work, and one of a job in the act of being assembled. These means have been found necessary to avoid loss of time between jobs, and to plan thus in advance requires a whole planning department comprising four functional foremen and a corps of assistants and clerks, all of whom take the place of the old-time shop foreman.

It is no mean problem to undertake to plan ahead and furnish jobs, procure and assemble materials at the machines, issue instruction cards covering each job, and route the work, so as to coordinate the entire performance of the shop in such a way that all the men and all the machines are kept in continuous operation in subservience to the point of the tool; yet such was the aim of the Taylor system.

FUNCTIONAL FOREMANSHIP.

The functions thus built up for the service of the tool, through that of the machine and the man, developed the following functional foremen:—In the shop, (1) gang boss, (2) speed boss, (3) repair boss, and (4) inspector; in the planning room, which is itself within the shop office, (1) order of work, or route clerk, (2) instruction card men, (3) time and cost clerk, and (4) shop disciplinarian.

The functions of these officials are sufficiently described by their titles, but it might be added that the gang boss is the erstwhile leading man; the speed boss is up on tools, machines and metal cutting; the repair boss is a millwright or machinist, up on belts; the inspector is the best journeyman in the trade; the order of work or route clerk is probably the ex-foreman; the instruction card men are the best journeymen of their trade, wise in time-study, the art of metal cutting, and the Barth slide rules for machine speeds, and for tool feeds, speeds, and depths of cut; and the shop disciplinarian may very well be the shop superintendent.

The inspector falls in a category all his own, and, in shops of the size of Watertown Arsenal, may have a half-dozen assistants. Under the system every job card is a contract between the management and the man in which a certain price is agreed to be paid with a premium when the work is satisfactorily completed. The inspector is the agent whose action in accepting or rejecting each job determines the payment. It must be seen that an inspector is indispensable in this connection, due to the premium system.

Under the day work system the foremen and leading men are the customary and proper inspectors, as there is no incentive to skimp on the part of the men; but under premium work such incentive exists and an independent inspector must intervene to regulate the quality of the work, especially when both the foremen and leading men are sharing their percentage of bonus upon the earnings of the men under them. The incentives of the day work plan are thus completely reversed, and this is the main reason why an inspection department is absolutely indispensable in premium work. The writer has known of an inspection department having been installed under day work, without the premium system, merely by virtue of an imaginary analogy with the Taylor system in circumstances that were not parallel.

The reasons for an inspection department under the Taylor system are real and paramount, and it is for that reason that it came with that system. Those operating a day work system would better carefully analyze the motives and incentives surrounding the work before imitating the inspection department of the Taylor system. There is another principle involved in the practical application of this work which consists in having an inspector who is the best man equipped to do the work that he inspects; otherwise, there will be lost motion and inefficiency.

It may be added here that in those private shipyards of to-day that have adopted a premium system in which the foremen and leading men share in a percentage of the bonus of the workmen, the shipbuilders should do themselves the justice to establish an adequate inspection department as a part of their own management like under the Taylor system, additional to the government force of inspectors, who are so sparse and whose work is so haphazard that it cannot intervene to settle the job-card premium contracts or to check each piece against the plans as it leaves the machine. Such a lapse on the part of private shipbuilders only means that defects are liable to be discovered at a deferred date, during the final tests,

only to require abnormal cost and time to rectify; and the quality of the output in the latter case may belch back its after-breath of bad work to plague the reputation and mar the good will of the careless concern.

There is another function performed by the inspector of the Taylor system, who has no delegated discretion but to reject the work if not up to plans and specifications. Only the management can waive a defect. An error resulting in the work, if due to the plans or instructions, is brought by the management home to the guilty party. The effect is educational and perfects the accuracy of the engineers, the draughtsmen and the instruction card men.

Reverting to the so-called functional management of the Taylor system, it might be well to add that there are two additional functionaries sometimes mentioned, the instruction boss and the lay-out man. The instruction boss, where employed, instructs the various other bosses in their duties, especially when they are first employed; instructs the workmen how to perform the work of their functions, and also teaches men of lower rating to do the work of higher class men in repetition operations. The lay-out man lays out, measures and marks the work before it is ready to be set in the machines, so there is no delay when the machine operative begins to set up the work under the gang boss.

There is an extreme limit in this subdivision of functions, as in everything else, which it is necessary to avoid, and common sense is the best arbiter to determine where the practicable limit has been reached, in the subdivision as well as the mechanisms of functionalism.

For example, in India the servant class is subdivided into a great number of "castes," and no one belonging to a particular caste can be induced to do a lick of work appertaining to a different class. A servant belonging to a certain class "will swing a wet blanket over you all night to keep you cool, but it would be wholly out of the question to persuade him to black your shoes or go to the post-office for your mail. He does not belong to the 'caste' which does those things. Hence, you must hire ten or a dozen servants if you expect to be served in all your wants. It makes work, don't you see?"

This illustration has been used by Mr. Gillette to show the obstacles sometimes placed by labor in the way of increased production. A practical illustration of a similar situation nearer home may be had in the list of artisans employed in the navy yards, where a great number of subdivisions in the trades have been made, introducing at times an inflexibility in the employment of labor under rules favored by labor against the employment of men in one trade to do the work of another kindred trade listed under a separate name. For instance, there are sheet metal workers, flange turners, frame benders, machinists, all-round machinists, electrical machinists, floor or vise hand machinists, specially skilled machinists, tool hand machinists, torpedo machinists. The difficulties as between not enough functionalism and too much functionalism depend upon in whose interests the settlement of a particular question is made. It is, as always, the same old question of whose bull is gored.

We have now seen the functional foremen of the Taylor system, and the great lesson that has been brought home to shop management in this country from which none can escape is that the number of foremen and superintendents must be vastly increased to take care of a modern shop of any size, especially a machine shop. Therein lies the great distinction from the so-called military type of management, where authority descended from the manager down the line through the superintendents, the foremen and leading men to the workmen. The truth was that the single foreman of other days, with an assistant foreman and a few leading men, was wholly inadequate to manage the work in the shop and keep it going at its best output.

It required Mr. Taylor to experiment and analyze the requirements and supplant the old-time foreman with a large number of bosses to perform the work that the erstwhile foreman was supposed to perform. There is no large machine shop to-day, whether it has the Taylor system or not, that has escaped reform in this particular. The great shipyards, that would roundly deny any part of the Taylor system, have increased their numbers of shop bosses, who perform duties covering the same ground as Mr. Taylor's functional foremen; and although the names are not the same, the men are so to all intents and purposes, and herein lies Mr. Taylor's greatest contribution to shop management, which has been adopted by all and escaped by none save in those shops so small that the manager is his own planning room and functional foremen combined.

The Taylor system manages by means of paper-work from the planning room. The great number of cards and tickets are sent out in advance covering each step of the work, and as each step is completed there is a return card announcing the fact which is the signal for the next step to begin, and so on by rote. Each successive step awaits a written notice before it can go forward. The job card is issued in its turn, the work board signals the assembling of materials and readiness to begin, the job completed must await the notice to the inspector, who must act before the ticket for the move man is sent out. There is no personal management following a job from start to finish in the old style, but every move is as if automatic by paper notice, and the number of papers and tickets is strikingly great.

The writer feels sure there is a happy medium which falls far short of all these paper notices and the long chain of dependent sequences. Mr. Taylor was essentially a master experimenter, and his shop system in its full bloom, with all the paper-work accompaniment, strikes the writer as a vast and comprehensive experiment framed so as to determine attainable limits, establish units of production, and bring their attainment to the knowledge of the individuals in the plant as a matter of education; after which it would seem best to dispense with a great deal of the paper-work and paraphernalia, save only for reference purposes sufficiently to maintain the units of output established for the shop.

To maintain the entire system indefinitely looks like continuing the experiment after its objects have been attained. In fact, the writer's view is borne out by what

was actually done in the Bethlehem and the Midvale shops, where Mr. Taylor's system was born and where applied by him in its fullest glory. The Bethlehem shops now ridicule the systematic paper-work of this system where nobody could move a peg until the paper notice made the circuit; they discarded the experimental paraphernalia, and, while retaining the ascertained units and standards of work, reduced the system to an ordinary premium basis with a larger number of foremen than were employed before Mr. Taylor came, but not so many as under him, with enough paper work to follow the jobs by the aid of more personal supervision on the part of these foremen.

The Senate Report of the Committee on Education and Labor of July, 1912, said, "The machine shop of the Midvale Steel Company, at Philadelphia, Pa., where Mr. Taylor perfected his system, has since his advent there abandoned most of it as an unprofitable method of management. Some of the features of the system which are obnoxious to workmen are still in vogue there, however."

None of the shipyards has had the Taylor system, but some of them have established a premium system, have increased the number of foremen, and introduced the job cards and work boards until they now have virtually the equivalent paraphernalia of shop mechanisms as are now used in the Bethlehem and Midvale shops, the main difference being that the two last-mentioned shops have had the advantage under the Taylor system of ascertaining limits of costs and workmanship, of units and standards, under the exact measures of that system, and have retained those measures, including slide-rules and data sheets, in their files and within the knowledge and recollection of their personnel; whereas the shipyards never knew their limits and possibilities in the different classes of jobs, never had time study or other standard than ascertainable under the Halsey system, where the shortest time in which a job could be done is that in which it has been done, which time is wholly determined by the workmen, and not by the management as in the Taylor system.

It is believed, in certain machine shops turning out work which is a mean between repeat work and miscellaneous work where it seems the Taylor system best applies, that it would be exceedingly worth while to apply the Taylor system for a couple of years in order to establish the shop units and educate the personnel, and then to abandon as much of the paraphernalia of the system as could be done while maintaining those units under the premium plan.

In repeat work of an extreme type it is believed that the Taylor system would not be of advantage, as in the case of the Springfield Armory, where General Crozier testified the results were standardized by seventy-five years' practice and compared very well with the Watertown Arsenal under the Taylor system, and that he did not expect to extend the system to Springfield Armory even if, after a full and fair trial, it should be extended to any of the other arsenals. It is judged, on the other hand, that the opposite extreme occurs in the miscellaneous repair work of a navy yard shop, and that this system would be unsuitable except perhaps to a limited extent, and then for only preliminary use in establishing stan-

dard units of work for ultimate reduction to the Gantt or Halsey premium payment plan, if that were legal, which it is not nowadays.

The writer has discussed the Taylor system at length, after presenting a synopsis of its leading features and purposes, with a view to evaluating it within its proper limits; and because it contains such a large proportion of what goes to make up the sum total of scientific management. Nobody ever again can develop shop management to the same extent as Mr. Taylor during his twenty-five years of practice and experimentation in which time he, a college educated man, held the following positions—apprentice, laborer, workman, machinist, gang boss, foreman, master mechanic, chief draughtsman, chief engineer, auditor, head of sales department, general superintendent, general manager, and consulting engineer.

Whether his system is good merely to put a shop on its feet, or to maintain permanently, may be a question remaining to be more definitely determined, but certain it is that the scientific methods and devices used by him will remain the best heritage of modern industry, and no shop can avoid them even though ignorant of the source of their derivation. Before quitting this portion of the subject, it is desired to refer somewhat further to the subject of time study.

TIME STUDY.

The primary object of a time study is to establish by exact measure the minimum time in which a job of work can be done. To perform a time study, first an analysis is made of the operations comprising a job by breaking it up into its constituent parts, second by examining and listing each part separately and measuring it in point of time, and third by the synthesis of reconstructing performance with the minimum necessary elements after eliminating all superfluous lost motion and waste energy.

Plate 32 shows an observation sheet and a graphical representation of a time study, Observation No. 1 being the conditions found before rectification, and Observation No. 2 the same after rectification. These figures are reproduced from "Cost Keeping and Scientific Management," by H. A. Evans, as they furnish a convenient illustration of the graphical features employed.

Motion study has grown out of time study, and it may easily happen that a time study may become a motion study for the most part. The best illustration of saving due to motion study has been furnished, I think, by Mr. Gilbreth, one of the pioneers in motion study, whose line of work in bricklaying was perhaps the most susceptible of improvement in this particular. It seems that the best illustration of the saving in cost and fatigue in this connection may be had by a citation of the language used by Mr. William C. Redfield in discussing the matter during the hearings of the Congressional Committee in 1912, as follows:—

"Assuming that the bricklayer lays 800 bricks a day and that he has to pick those up from the scaffold. He himself is a man of 160 pounds weight, and for the purpose of getting a result it may be assumed that every time he stoops down and

lifts up a brick he lifts one-half of his own weight, or 80 pounds. The principle is the same whether it be assumed to be 90 or 70 or 60. Assuming that he does so lift 80 pounds, or half his weight, every time he stoops down to pick up a brick, then in lifting 800 bricks he performs the duty in the day of lifting 64,000 pounds, or 32 tons. That is done for the purpose of lifting 800 bricks which weigh 8 pounds each, or 6,400 pounds, and he is performing a useless amount of labor equal to ten times that of his productive labor, or, in other words, he is exerting 64,000 pounds of work to perform 6,400 pounds of work. * * * The total amount of work done by that man that day on that basis is 35 tons.

"Now let us assume that those bricks are taken and placed alongside of him at such an elevation, kept constantly changed, that there is no lifting up the bricks, therefore, to be done, and no stooping, and that he is called upon to do work to the extent of these 3,000 bricks per day, then those 3,000 bricks which weigh 8 pounds each are lifted, so far as they are lifted at all, at an expenditure of 24,000 pounds of energy per day instead of an energy of 70,000 pounds per day, or 12 tons of work as compared with an energy of 35 tons of work. It is from these facts that you deduce your statement that a larger product of 3,000 bricks as compared with 800 is done with an exertion of 12 tons of energy, as compared with 35 tons of energy, or about one-third."

I have not verified the mathematics contained in the above, but the substance is obvious, and the example is particularly apt in demonstrating a case where waste energy is paramount and lost motion is considerable. The distinction between waste energy and lost motion here becomes accentuated. We can conceive of a job of light work performed upon an expensive machine where the lost motion may be great but confined to the movements of the body, the feet, elbows and hands, where waste energy and the consequent fatigue are at a minimum. The elimination of such lost motion mainly affects the time and cost of the output, the machinery being assumed to be large. That labor should oppose a time study involving the elimination of waste energy and fatigue, in work such as bricklaying, save through ignorance, is incomprehensible.

It is seen that the above illustration accentuates the question of motion study more than the question of time study, since anyone observing a man going through those two kinds of operation in performing the same work must necessarily have been able to measure approximately the difference, if he should have the question involved at all in mind at the time. But before the functional method of performing work in the shop was adopted and pointed out particularly, neither workmen nor managers thought of the difference as they would have done had the habit of placing the different classes of work under a scientific investigation been established. Another excellent illustration of the beneficial application of the functional method of performing work by a single workman through motion study is given in the testimony of ex-Naval Constructor John E. Otterson, U. S. N., before the Congressional Committee in 1912, as follows:—

"I recall one instance where my attention was drawn to a boat builder at work at his bench, and he was engaged in putting two boat planks together. The operation consisted of taking the two planks in this fashion and laying them together, end to end, and taking a butt strap and laying it across the ends of the two of them, * * * the purpose being to join them together. Now, he had to drive three screws in each end of that butt strap, six screws in all. Nothing was said to the workman, and as he did that operation—he had been a boat builder practically all his life since he started to work—he had his screws lying there, and his screw driver there, and his hammer there, and his brace and bit there (indicating in each case), and he took up his bit and bored one hole and then he took up his countersink in another brace bit and laid that down, then took up the screw and screwed it in with his fingers that way and got it started part way, then he picked up his screw driver and sent it home. He did that for those six screws. Now, as far as effort was concerned, he had lifted that brace and bit six times, that countersink six times, moved his hand six times for the screw, and picked up the screw driver six times, whereas done under other conditions which we endeavored to show him he picked up his brace and bit once and bored his six holes, and picked up his countersink once and countersunk them, and picked up the screw driver and started the six screws, and sent them all home."

I think these two examples are the best that have been cited as illustrating how, in the motions of a single man in performing any job of work, the great advantage lies in the functionalizing of his operations in the way here indicated so as to eliminate the lost motions. The rule is to reduce the series of operations to a system of repeat work so that, whenever the same operation is to be performed a number of times, all similar operations should be performed while the operator is in the act of performing that kind of an operation, and so on in rotation. When the work comprises such volume as to justify employing additional men it can then be broken up into functions and subdivided between different men, each one performing the same kind of repeat work constantly. In a boat-building shop, for instance, if the total output consists only of a very few boats, not enough to justify the employment of more than one man, the problem is for that man to break up his operations as indicated above and functionalize each different part in rotation one after the other. If, however, the boat shop is enlarged so that it turns out a number of boats and employs a number of men, the combined work can then be subdivided into operations and performed by several workmen, each continuously performing a part of the construction of each boat under the repeat work functional method. The best illustration I have seen of this feature occurs in the testimony of Mr. Otterson before the same committee, as follows:—

"I would like to bring out the case of the boat shop, the shop in which they build the small boats for navy vessels. The previous system of building a boat was that when you received an order for it you called in a first-class boat builder and

instructed him to build you a 40-foot sailing launch or whatever the class of boat might be, and he went out and collected his tools and went to the lumber pile and got his material and took it and laid it off and put it through the mill, and eventually assembled it into the boat and finished it. There wasn't any question but that there was a great deal of time lost, due to his drifting around from one thing to another and not having his work laid out and given the proper sequence, so we made an effort to functionalize the duties of various men engaged in the work in that shop. That is, we assigned to certain men the work of bringing the material into the shop, and to certain men the work of laying down the templates on that material and marking it off, to certain men the work of putting that material through the mill and taking it to the proper spot for the use of the boat builder.

"We then turned that material over to the boat builder, sawed out and shaped as per templates, and required of him merely to erect the boat; that is, he put the various pieces together, secured them, and finished them. The direct result of this was an immediate reduction in the cost of boats of a very marked nature, and in general the cost of production was somewhere about 50 per cent of the previous cost. In the case of Swampscot dories, the previous price had been about $90. Here are three boats which were built, one at $91, another at $84 and another at $87. Under the new system of building boats, where the work was functionalized and properly laid out, we built six boats at an average cost of $45 each. In the case of the Nahant dories, the previous cost was $95, and another one $86, and the cost under the new method was $44 per boat."

A very clear illustration of the principle involved is contained in a paper by Mr. R. Rankin in the Junior Institution of Engineers, of England, reported in London *Engineering,* October 13, 1916, as found in a British shop where time study and bonus had been introduced. The following is quoted:—

"In order to fix the task fairly, much investigation was necessary, and in the course of this investigation it was found that a great deal of unskilled labour was being done by the skilled men. Thus in fitting work to a template and subsequently joining the pieces together it was found that of a total average time of 11 minutes 15 seconds per piece only 38 per cent was spent in skilled labour. The work was accordingly rearranged. Four skilled men were united into a gang, each provided with a boy assistant, who removed the completed articles and cleaned up for the whole gang. At the same time a certain amount of carrying of the work from one place to another was abolished and some alterations made to the template and tools to give greater ease in handling and to reduce risk of accidental damage. The result was that whilst 2.37 completed pieces of work per skilled man per hour had been the average, the output was raised to 11 or 12 per hour. The minimum rate of pay was 20 per cent more than previously, but the labour cost of the work was reduced by 63 per cent. In another case in which certain work had been wholly done by skilled men the attempt to take times met with much obstruction, but the

records made showed that of the total time taken only about one-sixth was spent on skilled work proper, the rest being devoted to carrying and placing parts, setting up and dismantling tools, etc."

By altering the arrangements, the cost was reduced 66 per cent. In another case the output was increased from 6 to 36 pieces per hour, the decreased cost in labor being 66 per cent. In another case the output was increased from 6.5 to 30 pieces per hour per man. In another case the output was increased from 8 and 12 pieces per hour to 50 and 76 pieces per hour, and the shop was operated by 20 or 30 men in place of the 80 originally employed.

There have been many refinements, of course, not only in time study but also in motion study, and one of the latter has led to an investigation of the possibilities to be derived from the photographing of the motions of a workman performing a job of work, with a view to discovering some new possibilities not available to the eye-witness, and certain moving-picture machines have been invented with that end in view. The magazines have carried for some time past illustrations of photographs made showing such movements.

I do not conceive, however, that this class of representation could very well equal a personal investigation under the naked eye, for the very obvious reason that a photograph cannot possibly convey all the movements and surroundings as well as the naked eye. This proposition, it would seem, needs no illustration in order to establish such conclusion without any doubt. Such photographs, like other photographs that have been made to represent the reality, can only serve the purpose of conveying to an absentee a more or less accurate illustration of what has taken place in fact, but in no case can it possibly convey to said absentee all that could be available to the eye-witness under any conceivable conditions whatsoever.

If for the purpose of illustrating the theory to the general public through the publication of an article on motion study in the magazines, that purpose can be better accomplished with the accompaniment of photographs, but in the real work of examination and analysis itself it is believed that nothing will ever be found to justify its use as a substitute for a personal examination with the naked eye. Surprises, however, are always in order, and one of the most surprising exceptions occurring in the development of the moving-picture study of motions is illustrated in Plate 33, Figs. 1 and 2, which show the trace of the head of a golf club throughout the various curves made during a stroke. In these illustrations the player was placed in front of a charted background and an electric light was attached to the golf club near its head so that this electric light during the swing in a dark place would show the trace of the head of the club. Champion players of known excellent playing form were utilized in the experiments, and the trace of the swing established facts that were not recognized in the theories of teaching golf before that time. The golfer himself was oblivious to the exact nature of his swing, believed it to be different from that actually the case, and so described it in lessons to beginners.

This phase of motion study through photography was no doubt a development wholly unexpected to those who first devised the project, and can be accounted for as a necessary complement to the uses of the naked eye for the reason that the eye cannot possibly follow the quick motions of the golf club and retain any definite or permanent notion of the circles described.

Figs. 1 and 2, Plate 33, of the cyclographic pictures, as they are called by their author, Mr. Frank B. Gilbreth, represent one phase of his investigation of motion study from flashlight negatives, and Plate 34 has been added by the writer in order to show the final position of the head at the end of the stroke, so that the reader may connect it with the initial position of the head, as shown in the other figures through the curves traced by the electric light on the head during the stroke.

In this connection, the most forcible suggestion occurs in connection with the golf-teachers' rule about keeping your eye on the ball throughout the stroke. It is seen that such is not in reality accomplished, but that only the nearest approximate attempt, through the concentration of the will power, has the effect of maintaining the head within those spaces necessary in which to accomplish the desired result. To keep your eye on the ball through a swing of the head, as shown in the curves, and end up facing fully in the direction of the strokes, resolves itself into a discrepancy of which these pictures are the best explanation.

Time study proper develops the standard time in which a job can be done, after all lost motions and waste energy have been eliminated, and the result becomes a task time on which to base a bonus; and to obtain this the best efforts of a first-class man are assumed as essential, and these are secured through a course of mental treatment and a bonus. The stop-watch has gotten itself into bad odor in many quarters by being the instrument for measuring a time study, but how else can a job be measured save by a time-piece? From the very start the scheme was obnoxious to the person being timed, which is evidenced by the use of a hidden stop-watch in the recess of a specially prepared note-book, the object being a deception practiced upon the workman by timing his work while appearing only to take notes, without his being aware of it.

Herein lay a crucial point in the traditional distrust and suspicion existing between employer and employee. Without a time-piece the workman had it entirely in his own hands to determine the minimum time of a job, and there were no exact measures save in the records of past performance in the shop, if indeed such records were made and kept available for comparison on repeat work. Undoubtedly the time study reduced a job to its lowest terms, and this was to the gain of the management more certain and of greater measure than to the workmen. It stripped the workman of all means of soldiering and placed his efforts for the first time under exact measurement. He did not like it. His means of combating capital was at once removed. He could no longer limit output or nurse his job.

A scheme that conflicted at once with the sum and substance of policy of organized labor was not to be instituted without a battle royal. The race of the slow was not to be discarded in favor of a scheme that rewarded upon individual merit determined by "a cold and inhuman measure" that ignored personalities. It is not

to the discredit of labor that it has aimed its policies towards the attainment of such measures as a minimum wage and other ends in protection of the weak of its members, the old, the halt, and the lame. The ablest of the workmen were not to be afforded the organized support of the great majority in winning higher wages by a system based on merit, but the poorest were to be sustained by all the power of labor, no doubt because the merit system promises to cast aside the weakest members as they have been cast aside so ruthlessly in the past, and it is perfectly natural for every member of a labor organization to protect a position or condition in which he is quite liable to find himself at one time or other in the period of his lifetime.

What man is there but stores up for his old age? The laboring man cannot accumulate capital; why should he not strive to keep conditions so that he can feel reasonably sure to make a living wage when he grows old? He remembers the dismal history of the past in those particulars more than he trusts the humanitarian motives of the new ideals in management that now begin to profess to care for the weak members; hence, in order to lay up for a rainy day, in earning ability at reduced powers, organized labor would adhere to a policy which incidentally harbors the sluggards and shields the soldierers who hide behind the legitimate prejudices of honest labor. In order, therefore, to obtain the consent of labor to cooperate on a basis of time study it has been necessary to change the workman's mental attitude to that as if a partner of capital, and to do this the bonus has been applied to increase his earnings largely, and a system of welfare work introduced which not only promises to utilize the weak at such scientifically selected work as they can best perform, but also promises even so far as insurance against loss of time by sickness.

Such a law is now pending in Massachusetts, and even a retirement pension, already adopted in somewhat unique cases, is being seriously discussed among employers. Perhaps the future may bring its own protection to the weak, when there will be no reason for conflict between capital and labor over a complete show-down on performance in the shop.

Assuming all obstacles in the way of complete cooperation to have been swept away, the question then becomes:—How far will the time-study-task-and-bonus method pay? The index to this is obviously in the quantity and proportion of repeat work involved in the operations. The time to do a job is for use only to set a task when that job is repeated. If there were a million jobs a year and none of their operations were repeated, time study would not apply in a single instance and would be wholly superfluous. The profit is in proportion to the number of times an operation is repeated.

Let us take a case where the repeat work is at a maximum, as in the case of a shoe factory where each operative performs only a certain function on one machine. Each shoe undergoes, say, thirty operations from start to finish as it passes through the circuit from machine to machine. A given operative runs one shoe after another through his machine, a function constantly repeated *ad infini-*

tum—like the functions of killing and packing a hog at Armour's in Chicago or Kansas City, or like building a Ford car in Detroit.

What can time study, bonus, and Taylor's functional foremen do for a shoe factory? It can take an old-fashioned one that has never been analyzed or systematized and put it under investigation and analysis; it can apply the motion study to provide the best attitudes and movements, and accommodate the body with the proper chairs, benches, shelves and other auxiliary equipment necessary to attain the fewest and most comfortable motions; it can establish the proper units of time of the different operations; and it can speed up the machinery and record the same.

This process could thus determine the units covering the operations of the machinery and the men and the different classes of shoes in the shop. But it is seen that once the maximum production of a machine is known and that of a workman, in a shop where the number of kinds of operations are limited and are constantly repeated day after day and year after year, there is no justification in maintaining an expensive Taylor analytical system after these units are once determined and have become known to management and employees, although it must be seen that the value of such an analysis might be immense and even indispensable in certain shops.

I regret there are not firms of efficiency engineers who might offer to set up the Taylor system in a shop, analyze and systematize the work, establish the proper rates on all classes of repeat work, educate the personnel to know said rates and how to attain them, and then agree to remove all the analytical mechanisms save only those that the management found absolutely necessary to keep the rates going, and the latter could further simplify on their own recognizance as the work grew more familiar after the efficiency engineers had departed.

The trouble with such a proposition is that, like other humans, efficiency engineers naturally want to make the most out of their gold mine, like the Forty-niners in early California who made more money by bull-ing and bear-ing their gold-mine stocks on the Stock Exchange than they did by digging gold out of the mines. So much for the shoe factory, and other purely repeat work shops.

There is a middle class of shops, where there is a mixture of miscellaneous and of repeat work. The Watertown Arsenal is one of these, and, though it deals mainly with gun-carriages and projectiles, repeat work true enough, in a certain sense, in the large; yet the details are of such a high degree of complication as to introduce a great deal of variety in the jobs.

The Taylor system was applied here to great advantage, there being enough repeat work to profit by time study to a large extent, and enough different kinds of repeat work jobs to require an analytical organization to hold the records and apply them to a large proportion of the current work. The records showed the saving due to the installation of this system was about 66 per cent over what it was before, in which the men received one-third more pay and the Government one-third more profit. A better output cannot be conceived of than in these shops, for the application of this system, which I think is a criterion for that reason, and also for the

reason that these shops received the personal attention of Mr. Barth and Mr. Merrick, collaborators of Mr. Taylor, and were administered with a high degree of intelligence and ability by the representatives of the War Department.

General Crozier and Colonel Wheeler, in their management of this work, no doubt secured the maximum benefits on behalf of the Government, and extended the maximum of consideration and humane treatment to the men. Nobody save one in a like relationship can fully appreciate the motives of fairness operating in a like case of control, as distinguished from shops operated by men in a position to profit financially from the returns of the labor they control.

A private shipyard engaged in building ships is in an extreme category, though not so extreme as a navy yard engaged in general repair work, with respect to the infinite variety of jobs and the lack of steady recurrence of repeat work. A capital ship of the Navy embodies greater quantities and varieties of work perhaps than any other manufactured object ever built in the history of the world, and if you take the general run of navy yard repairs it may be far indeed between repeat jobs. Here, time study would have its narrowest field of application, and it is believed not enough to justify the Taylor system as a whole even in the machine shop, although undoubtedly there is a considerable field for the application of the bonus, and to such cases time study would apply. Where jobs are not identical but are similar, or have component parts that are identical with the component parts of other jobs, estimates can be made from previous records in the case of the Halsey system or from time study results, which are quite sufficient and valuable for the purpose of applying a bonus.

The objections raised to time study by the workmen may be illustrated as follows. Mr. O'Leary testified before the House Committee in 1911:—"Our objection is to having someone standing over you as a slave driver; the stop-watch is equivalent to a whip; you might just as well have that." There is something in psychology which suggests the above idea in the operation of time study, as may be gathered from the instances of its having been done secretly from a concealed stop-watch in the pocket of a note-book, the object being to avoid getting a rise out of the workman on account of this very effect.

Mr. Taylor practiced and suggested this procedure as a facile way of getting by with it. The cause and effect reminds the writer of an incident that occurred under his observation on an Alabama plantation when he was a small boy. A man named Harris, of a Virginia family of has-beens, had drifted from home, had found himself of such low estate as to be obliged to become a plow-hand, and was plowing a field of corn. Suddenly he spied a negro sitting on the fence watching him plow. Harris stopped, yelled at the negro, and of all the choice oaths that ever man uttered, he ripped out the most exquisite and hurled them at the negro for presuming to sit on the fence and watch him work.

The action was immediate and spontaneous, and this psychological effect was akin to that suggested in the testimony of O'Leary given above. That this has been recognized in higher quarters is shown in the discussion of Mr. William C.

Redfield during the Committee Hearings in 1911, as follows. In speaking of using the stop-watch he asked General Crozier whether long and oft-repeated observation would not give as good result as the time study, and said:—

"Then, having done that over a period of time, why is it not possible for me to take their product, not for an hour, a day or a week, but extending, perhaps, over several successive runs and not just one, and so get a result, which is the more accurate as it is extended over a larger period of time, and takes into account and makes allowances for the difference, not only in men, but other things, such as when a man is well and when he is not, whether things are all right at home or not, and so, on the whole, arrive at a fairer and more just average of product per man? Why is not that all quite as accurate and, perhaps, a little more kindly and just? That is to me, I confess, the crux of this whole question. Now, why is not the outline I have suggested to you at once the more kindly and more accurate?"

These sentiments give a clue to the opprobrium that has grown up around the word "task," which Mr. Taylor determined as the minimum time by a first-class man. After the system was attacked by labor, the testimony of General Crozier and Mr. Barth showed that "task" distinguished between the time the job "can be done" and the time in which it "ought to be done," and the latter became the task time. That is, all elements being allowed for, not heretofore specifically set forth in particular, comprised, nevertheless, the following elements, so that task time equals minimum time, plus time for the mental process preceding the act, plus time for rest due to fatigue, plus time for the lost motions sought to be minimized by motion study.

The report of the Wm. B. Wilson Committee, signed also by Wm. C. Redfield, stated thus:—

"The time study of the operations of any machine can be made with a reasonable degree of accuracy, because all of the elements can be taken into consideration in making the computation. A machine is an inanimate thing—it has no life, no brain, no sentiment, no place in the social order. With a workman it is different. He is a living, moving, sentient, social being; he is entitled to all the rights, privileges, opportunities, and respectful consideration given to other men. He would be less than a man if he did not resent the introduction of any system which deals with him in the same way as a beast of burden or an inanimate machine. * * * There is need for production at the lowest cost, but no economic necessity can justify requiring workmen to speed up to the highest point which they can continue from day to day and from year to year, even without injury to their health and strength. To place workmen in a position of that kind is to put them in the position of a beast of burden which is required to go on from day to day performing a given task."

The above words are quoted here because they best represent the views of

labor and were those adopted by Hon. W. B. Wilson, one of the foremost representatives of labor and present Secretary of Labor, as well as by Hon. Wm. C. Redfield, the present Secretary of Commerce; and to the writer they seem to breathe the personal views of Mr. Redfield, who is a large employer of labor—one who has risen to success from among the new school of the humane-welfare-ideal class of managers, and is in full sympathy with the larger purposes of scientific management, in the elimination of waste.

The point is stressed at this juncture because its full meaning must be taken into account when matched against the assurances of the efficiency engineers that the new measures are not intended to offend or injure or degrade the workmen, but are in reality a blessing in disguise. The breach between these two points of view is wide enough to cover up an ample margin of real lost motion as well as soldiering among the loafers, to contain the traditional distrust and suspicion existing between the contracting parties, and to account for the rejection by the Government of the time study scheme for use in government shops.

I think the language of Mr. Taylor's book on "Shop Management" reveals in certain parts an impression of harshness, of abruptness in dealing, and of exacting requirement, always in favor of the employer and contrary to the interests of the worker. This fact gave wings to the opposition of the men who built mostly on what they feared might follow from a new and revolutionary scheme they did not understand, but which promised to de-capitalize the skilled mechanic and reduce him from an all-round man to a mere automaton—a functionary performing a single operation, unless indeed he were displaced altogether by an unskilled laborer or helper, employed at low pay, and trained to perform forever the monotonous repetition of a single function.

Add to this the campaign of literature that burst forth in all branches of the public press at the time, heralding the new find and describing it to the country at large in the glittering generalities of bombastic language, offering explanations that did not explain and descriptions that did not describe, each one building a new sky-scraper on Mr. Taylor's foundation. Many of the technical and semi-technical men of the country did not understand the thing, but were only confused by trying to. Only Mr. Taylor's book explained, and that only in part, and the vast majority did not have the book, which contained most that was really tangible, and which only the labor organizations were quoting, in its adverse portions, in furtherance of their opposition to it.

These glittering generalities of the press no doubt had an adverse effect upon public sentiment and, everything considered, it is certain the case was prejudiced in advance by the campaign of literature in every direction, resulting finally in the existing prohibitive legislation brought about mainly by organized labor, assisted by the general confusion.

There is no doubt a happy mean between the two extremes represented by the conflicting interests, attainable through the humane treatment of the worker on the one hand and the development of the economic needs on the other. Labor-

saving machinery was opposed by organized labor, but it came as surely as its economic advantages were real, and as its benefits were shared by workman and employer and public alike. Time study possesses equivalent economic potentialities and may be only ahead of its time. Some day the workmen may not feel grieved at the stop-watch; the partnership between capital and labor may develop into such a mellow state as to break down all remaining distrust and suspicion. You can strike a friend a heavy blow, in fun, when he knows you mean him no harm; but you cannot with impunity even so much as knock a chip off the shoulder of an avowed antagonist.

THE PREMIUM.

The terms "bonus" and "premium" are both used by different authors to express the same idea in wage systems, and may be considered as equivalent terms. In most of these systems nowadays the employee is guaranteed his day's wage, which is established upon a fixed basis, and the premium or bonus is the additional amount paid for performing a quantity of work over and above the amount established by the base rate. This base rate was formerly established by estimate from the shop records, being the best time in which the average workman could perform a given job. Such a method was in vogue when the Halsey premium-payment plan was invented and was used under subsequent similar schemes up to the time when Mr. Taylor introduced the time study by which the base rate, or task, as he called it, was determined, and the premium in this case was called a bonus, and hence the task-and-bonus system, as it is called.

In day work the workman sells his time to the employer, and there is no measure of output. It is only necessary for the employee to perform a sufficient amount of work to satisfy his employer that he is earning his wage. This can be done and has been done by performing eye service especially when watched, to create the impression of doing a volume of work when no such volume existed. The writer has seen a sheet-metal shop full of employees, each one hammering away at benches and anvils as if his life depended upon it when, as the result of a casual examination, it was found that perhaps 75 per cent of the imitation work was bogus, resulting in a general lay-off the next day. Under any system of measuring output this great defect of the daily wage system could not occur. In order for the day-work system to be at all acceptable, close personal supervision of the men by honest bosses is necessary, and a planning department is essential under any system of management.

Plate 31 contains a number of charts which have been reproduced, most of them, from the *American Machinist,* June 13, 1912, in an article entitled "A Review of Existing Wage Systems," by C. B. Auel, which seemed to be in the best form for introduction as an illustration here. Anyone interested in the particular details of this system is recommended to read that article in addition to the other works upon the subject. Fig. 1, Plate 31, exhibits the rates and wages of the day-work system. The rate is 25 cents per hour, and the wages, corresponding to the number of hours on the side scale, are determinable on the bottom scale.

It is to be noted that in the day-work system there is no incentive for the workman to produce a greater output in a given time, since if he does so he receives no extra reward but all of his extra output accrues to his employer; whereas there are incentives for him to turn out a less product in a given time, since by so doing he can nurse his job and contribute to the general policy adopted by labor of limiting output through hatred and fear of abundance, the idea being that the more goods created the less will be the future demand for work.

Piece work is the opposite extreme from day work, and is illustrated by Fig. 2, Plate 31. The price per piece, as shown in the figure, has been adopted as $1.15. The sketch shows the rates and wages for one piece. If the workman completes the piece in five hours, his hourly rate is less, if in one hour his hourly rate is equal to the price of the piece, and he is then free to begin another piece or other work, thereby increasing his earnings in proportion to the number of hours saved on the job.

Under this system the incentive to the workman is the greatest of all, as he and not the employer receives the benefit of all the direct wages involved in the increased output—that is, if he gets a dollar a piece and is supposed to do a piece in two hours, if he should so increase his output as to do two pieces in two hours he receives double pay instead of single pay during the two hours, and his employer receives no part of his increased output. The employer, however, benefits through a reduction in the overhead charge per piece, since in the case where the employee turned out one piece in two hours, which we will say is the base time for a first-class man, the overhead charge on which we will say is 50 per cent; if the employee turns out two such pieces in the two hours the overhead charge per piece will be only 25 per cent instead of 50 per cent, and the employer profits thus in a reduction of the overhead charge in proportion to the increased output.

It will be seen that this is the opposite effect from day work, the tendency under piece work being to increase the output and that under day work to increase the time, and the overhead charge increases in proportion to the amount of time consumed on a job. Piece work is essentially a bonus, or premium, system, in extreme measure, a different form from the accepted sense of these terms, but it is such nevertheless.

Straight piece work may now be used by the Government, as it is not in conflict with existing law. The law as it reads forbids the making or causing to be made with a stop-watch or other time-measuring device a time study of any job of any employee between the starting and completion thereof, or of the movements of any such employee while engaged in any such work, and forbids payment of any premium or bonus or cash reward to any employee in addition to his regular wages, etc. That is to say, if piece work is employed it must be pure piece work, and no daily wage can be guaranteed in connection therewith, else the piece work becomes a premium or bonus system, in the sense of this law, in view of such guarantee of the daily wage.

The peculiar thing about varying jobs is that there are so many circumstances

rendering inaccurate the estimated unit time that it has been found necessary to guarantee the workman his daily wage, otherwise a mistake in the wrong direction might cause the workman to lose his capital, which is more than he can afford to do. It is for this reason that the guarantee of the daily wage has been established in the various premium systems. Therefore, all jobs which are not so cut and dried as to have their unit time determined accurately in advance are not susceptible of being applied to piece work by the Government under existing law. This effect necessarily minimizes the application of piece work and leaves it available for such classes of work as plate, angle and rivet work, etc., to which it has heretofore been successfully applied for a long time in the past on account of the ability to measure and count the output per man.

Certain other classes of work, such as painting and manufactured articles, involving a standard output or repeat work, are available, but the sum total is comparatively small and limited to that which has heretofore been established under the straight piece-work rates applying in navy yards and private shipyards. It avoids the application, however, of that class of piece work which has been so called, but which is really premium contract work with the daily wage guaranteed, that has been heretofore and is now used in the private shipyards but which has become unavailable for governmental use.

Piece work, as has been seen, is peculiarly suitable to that class of work which can with facility be counted by the counters without great difficulty or mistake, and consequently the units become very familiar to all alike, including the workmen, and the workmen may be able to take advantage of this fact and to control their output and limit it to a certain agreed-upon amount among them. This is one of the bad features of piece work to which objections have been raised in the past by employers, and an example to show how this has been done may be cited from the report of the hearings of the Congressional Committee in 1912, where a report from the Commanding Officer of the Rock Island Arsenal, dated October 21, 1908, to the Chief of Ordnance, War Department, Washington, D. C., showed the following exhibition, which is sufficiently striking to be reproduced here:—

"(*k*) The following table gives a list of the polishers in the armory shops, showing the amount made by each one on four different days. Examination of this table will show that the amounts vary from $3.23 exceptional to $3.52 per day, which, of course, will be impossible were every man to do a proper day's work.

Polishers	August 27		August 28		October 16		October 17	
	Received	Worked	Received	Worked	Received	Worked	Received	Worked
		Hours		*Hours*		*Hours*		*Hours*
J. McPortland	$3.43	8	$3.48	8	$3.43	8	$3.48	8
A. M. Botsford	3.44	8	3.45	8	3.46	8	3.45	8
J. W. Carey	Abs.	....	Abs.	....	3.46	8	3.50	8
T. Crannell	3.44	8	3.44	8	3.45	8	3.45	8
W. A. Drayton	3.41	8	3.45	8	3.45	8	3.45	8
E. O. Fisher	3.43	8	3.48	8	3.45	8	3.46	8
C. Frederickson	3.35	8	3.43	8	Dis.	Sept. 25	....	....
G. E. Frodell	Abs.	....	3.44	8	Abs.	....	Abs.	....
A. J. Hill	3.52	8	3.41	8	Dis.	Oct. 3	....	....
F. Holmes	3.41	8	3.45	8	3.46	8	3.47	8
L. Hulsbrink	3.52	8	3.41	8	3.47	8	3.44	8
H. H. Ives	3.45	8	1.73	4	3.44	8	3.44	8
Roy Kelly	3.41	8	3.52	8	3.45	8	3.50	8
A. G. Kirck	3.47	8	3.51	8	3.46	8	3.46	8
E. P. Lerch	3.42	8	3.46	8	3.43	8	3.50	8
C. Lidders	3.52	8	3.41	8	3.46	8	3.40	8
J. Lindvall	3.46	8	3.42	8	3.46	8	3.46	8
J. A. Mauget	3.41	8	3.45	8	3.45	8	3.45	8
F. M. Moody	3.41	8	3.52	8	3.45	8	3.45	8
J. McTighe	3.49	8	3.46	8	3.49	8	3.47	8
W. C. McTighe	3.49	8	3.49	8	3.48	8	3.45	8
E. Rathbone	3.52	8	3.41	8	3.44	8	3.44	8
F. W. Roberts	3.45	8	3.46	8	3.45	8	3.45	8
E. P. Rome	3.45	8	3.47	8	3.23	8	3.35	8
F. W. Rudolph	3.45	8	3.45	8	Dis.	Sept. 8	....	....
I. Snyder	3.46	8	3.46	8	Dis.	Oct. 3	....	....
J. Sillivan	3.44	8	3.45	8	3.46	8	3.45	8
E. B. Taylor	3.45	8	1.75	4	3.45	8	3.30	8
C. Bertman	3.44	8	3.36	8	Dis.	Sept. 8	....	....
W. Swallow	Abs.	....	Abs.	....	3.48	8	3.47	8

It does not stand to reason that all polishers have the same speed, skill, and accuracy. The present flat-day rating and practice among them make them all absolutely equal in every qualification, which is entirely opposite to the universal

principles that no two persons have the same qualities and attainments and that no two persons are equally suited for the same position. Were it otherwise, anyone could properly fill any position. As expressed by one of the manufacturers in this vicinity, "the laborer's capital is his ability to produce."

It is obvious from this exhibit that an understanding existed between the men in the shop that they would turn out only a certain agreed-upon equal amount of work per diem, which understanding was known to exist by the officials of the establishment and of which the above exhibit is the best evidence. The results here shown are parallel with the unionized policies of labor to limit an equalized production to the rate of the slowest men in the shop.

Piece work *per se* has introduced a great bone of contention between employer and employee due to its inflexibility; the workmen, as shown, receive all the increase in direct wages, and the work is essentially of such a nature that the workman can become familiar with the unit time required to do a given job. Thereafter, if a mistake is made in setting the rates too high, the only recourse on the part of the management has been in the past to cut the rates, and the workmen have thereupon become distrustful of the system. Also, under the piece-work system, where other operatives are on the day-wage schedule, in slack times and in periods of depression when the day-wage rates throughout the country and throughout the establishment are reduced, any cutting of the piece work is received by the workmen with opposition and is viewed with the same suspicions that have grown out of the cutting of rates, which have generally been applied under conditions in the past that they have not always fully understood. Consequently there has grown up a great deal of suspicion on the part of workmen against all premium systems in which they attribute lack of good faith and fair dealing in fixing rates.

The efficiency engineers have endeavored to meet this criticism by proclaiming it to be essential that premium rates should not be cut or altered in any way, excepting when a new and shorter method of doing the work has been discovered. These protestations have been superinduced by the workmen's opposition, and the object has been to break down the distrust of the workmen; consequently one of the cardinal principles of scientific management has developed into a preachment of the gospel of the fair deal.

While it is possible under time study to convince workmen that changing the method of doing the work or of introducing new machinery in view of the microscopic analysis available for such convincing explanation, yet in piece work there is no such analysis available, and so piece work might be called the father of the spirit of distrust surrounding the practice of rate-cutting and consequently the father of the fair deal doctrine.

Fig. 3, Plate 31, exhibits the Halsey premium system, at an allowance of 33 1/3 per cent of the direct earnings to the workmen. Mr. Halsey appears to have been the first to invent a wage system of this kind, and since his system a number have

appeared by other authors which have not varied greatly in principle, but only in the details of application, whereby the division of direct earnings between employer and employee is varied sometimes in favor of one and sometimes the other. This plan is a midway scheme between the day-work and the piece-work plans, in which the direct earnings are divided between employer and employee, Mr. Halsey refunding an allowance from one-quarter to one-half of said earnings to the workmen, in which he found that about one-third was suitable in most cases within his experience.

This system was adopted by a firm in Glasgow, Scotland, called the Weir-Halsey system, from the name of the Scotch firm, the principal characteristic being that the direct earnings were divided equally between employer and employee, at fifty-fifty. This is the proportion of the division of output that has now been generally adopted under this and other systems in work parallel to shipyard work, and is used also under the Taylor system at the Watertown Arsenal, as well as under the Halsey system at the Bethlehem Steel Company and Fore River Shipbuilding Corporation, as well as other places that might be cited. In the Halsey plan, however, the unit times were estimated from the back records of the shop, and there was no time study as under subsequent systems.

However, it is immaterial how the unit times are determined, whether by time study or estimate, in so far as the application of the premium plan is concerned, as it may be applied to either. The Halsey system has the great advantage of simplicity, and I prefer to treat of plans by other authors which approximate to the Halsey plan, in the same general terms, as it is doubted that small variations and refinements are of any advantage, particularly as they tend to introduce difficulties in the accounting. At the present day, with the experience accumulated through the use of the various systems, the Halsey system would seem best to answer all purposes, as the division of profits between employer and employee has been fully analyzed through the results of time study, and all uncertainties have been practically removed.

Figs. 1, 2, and 3 have been exhibited to show the two extremes and the mean, in the division of the increased output between employer and employee. Fig. 4 exhibits, upon the same plate, the other principal wage systems, so they may be examined comparatively. Of these the following general descriptions may be made, in which only the leading features are brought out, the general characteristics being as indicated on the plan.

The Rowan system, named after a firm in Glasgow, is very similar to the Halsey system, but was made so as to prevent the rates rising too rapidly, at the expense of the employer, in the case of a mistaken rate where the employee was able to very greatly reduce the time. It will be seen that if the unit time were set at say five hours, and the workman was able through a mistake to do it in one hour, the firm would be better protected than with the Halsey system. For slight variations between the unit time and the performance the two systems are practically

the same, and the Halsey system is in favor of the workman during those times. Consequently, a combination of the two systems has been used, called the Halsey-Rowan system, whereby the upper part of the rate and wage curves of the Halsey system are used, and the lower part of the Rowan system. The curve of the Rowan system is obtained from the following formula:—

$$\text{Time taken} + \frac{(\text{time limit} - \text{time taken})}{\text{time limit}} \times \text{time taken}) \times \text{hourly rate} = \text{wages.}$$

The curve of the Halsey system is obtained from the following formula:—

$$\text{Time taken} + N\ (\text{time limit} - \text{time taken}) \times \text{hourly rate} = \text{wages,}$$

where N = any fraction, as 1/4, 1/3, 1/2, etc.

The Cardullo system, shown on Fig. 4, is very similar to the Rowan system, in which the curves are obtained from the following formula, which is the same as that for the Rowan system, excepting for the introduction of an additional constant indicated below:—

$$\text{Time taken} + N\,\frac{(\text{time limit} - \text{time taken})}{\text{time limit}} \times \text{time taken} \times \text{hourly rate} = \text{wages.}$$

This system is quite a diminishing premium system, a device to protect the employer to a greater extent than the Rowan system against mistakes made in setting the rates, and is the more undesirable for that reason. I believe that since the invention of the Halsey, and especially the Rowan and Cardullo systems, that experience has shown it necessary to permit the employee to share a greater proportion of the savings, as indicated in the above comments, which have now been extended to the maximum Halsey rate of 50 per cent, as adopted in the Weir plan, a Scotch form of the Halsey system. The safeguards against mistakes in setting the unit times have been eliminated in those plants where time study has been available, and a greater degree of careful analysis in the accumulation of unit times under a higher degree of accurate management has rendered more generally practicable the use of the fifty-fifty division between employer and employee.

The Emerson plan is a variation of the Halsey plan, though differing in the details and in the application. As may be seen from Fig. 4, it approximates fairly close to straight piece-work rates, in which the workman is given nearly all of his direct savings in wages, the management being supposed to profit in the shape of the reduced overhead. This plan contemplates a task based on time study, and to that extent grew out of the Taylor and the Gantt systems, although the curve more nearly resembles physically the Halsey plan. The Emerson plan had coupled with it an efficiency rating of the workmen, 100 per cent representing completion in task time. Fig. 5, Plate 31, shows the Emerson plan, drawn upon a scale as

presented by its author. The bonus allowed is determined from a bonus curve in which the percentage of bonus varies with the percentage of efficiency, being 10 per cent bonus for 90 per cent efficiency, 20 per cent for 100, 21 per cent for 101, 23 per cent for 103, 30 per cent for 110, 70 per cent for 170, 115 per cent for 195, etc. The modified formula of the Emerson system is as follows—

$$(\text{Standard time} \times \text{hourly rate}) + (\text{time taken} \times \text{hourly rate} \times 20 \text{ per cent}) = \text{wages.}$$

As may be noted, the Emerson system leads into a high degree of refinement, for the stated object of being more humane and considerate to the men and of acquiring greater accuracy in the fixing of the earnings according to the precise efficiency of the men; and the wage curve has consequently been smoothed out into a more harmonious curve towards its point of juncture with the straight line of the day-wage system, as may be seen by examining Fig. 4. It does not seem that any crucial point exists in the neighborhood of that part of the curve and no particular advantage is perceived in the arrangement; on the contrary, it would seem to introduce unnecessary complications in the bookkeeping. The name "Emerson Efficiency Plan" has been given for the reason that it attempts to evaluate, in connection with the payment system, the work of a single man, or a group of men, or of the whole shop, upon a percentage of efficiency which, however, might be employed in connection with any of the other wage systems if one desired.

The Taylor differential piece-work system was presented in a paper by that author read before the American Society of Mechanical Engineers, June, 1895, and is illustrated in Fig. 4. For a given job two rates are established, a high rate if done within a given time, but if done in a greater time a low rate to apply. In the case of Fig. 4 the high rate is $1.44, and the low rate $0.96. The object of this plan was to give a very high reward for the accomplishment of a task which only the best class of workmen could perform, and to give a very low rate to a man that fell below the standard by whatever small degree. The effect was to eliminate second-class men altogether. The gain, it will be seen, on behalf of the employer, was to reduce the overhead charge practically in two, which was Mr. Taylor's experience in a certain particular class of repeat work.

The plan itself follows Mr. Taylor's motives of high reward for efficient performance coupled with punishment for shortcomings. It is believed this is the original of the so-called "task-and-bonus system," the task being set by time study and the bonus being the reward for accomplishment within the time set. The Gantt system, also exhibited in Fig. 4, is in principle identical with the Taylor system in so far as the task-and-bonus part of the curve is concerned, up to the point opposite the task time. Beyond this point, however, the Gantt plan follows the line of the day-work wage so as to avoid the harshness of the minimum Taylor rate. That is to say, the Gantt plan sets a task based upon time study unit time with high reward for performance thereunder, but if the task is exceeded the workman

falls back on his daily wage which is guaranteed him. The formula of the Gantt plan is:—

$$\text{Standard time} \times \left(\text{hourly rate} + \frac{\text{hourly rate}}{N}\right) = \text{wages},$$

where N equals any whole number.

There are a number of other variations of these systems which may be barely mentioned in passing. The Manchester piece-work system was so called from its use in Manchester, England, it being straight piece work coupled with the day's wage guarantee. The MacLane double-rate premium system was suggested by that author, of the Westinghouse Electric & Manufacturing Company, the two rates being applied from month to month to a workman, depending upon whether the base time set for the work was exceeded or not for the previous month. This of course would introduce complications in the bookkeeping.

The Parkhurst system is practically identical with the Emerson system, excepting that a straight line is used in the curve instead of a parabola for the small gains at low efficiencies. The group premium or contract system has been largely used for certain classes of work and is applied either on the premium or straight piece-work plan. It has been largely used in contract or straight piece-work rates in some of the large shipbuilding companies in this country, and to great advantage in all sorts of installations aboard ship in the process of construction.

A job of work is figured out based upon past performances bolstered up by auxiliary estimating, and the contract or piece-work price let to a mechanic, called sub-contractor. When the job is completed this sub-contractor is supposed to share his earnings with the men, and the management brings, or should bring, all wages paid the gang under review, which is necessary to secure fair dealing on the part of the sub-contractor with the men who are employed, not by him, but by the company, and furnished him to carry on the work. The objections to this system are obvious but are surmountable, and the system has been used extensively.

Also, in certain shops, such as a tin shop or a pipe shop, where the bulk of the work can be carried out only by groups of men, as distinguished from jobs that can be performed by individuals, the group premium plan has been and is now used in certain large shipyards, where the workmen are permitted to share half and half the savings among the group of workmen involved, in which each man gets his *pro rata* share, upon the equivalent of the Halsey plan.

There are certain other so-called gain or profit-sharing schemes employed by various manufacturing firms throughout the country, which method was followed by Mr. Henry R. Towne of the Yale & Towne Manufacturing Company, where the employees are permitted to share in the general profits of the firm. Mr. Charles M. Schwab, of the Bethlehem Steel Company, prides himself upon his 20,000 partners, and, as is well known, it has been a policy of that company now for a great number of years past to arrange for their employees to own stock in the company.

Other companies allow a certain proportion of the earnings, over and beyond

a certain amount, to be distributed among their employees, sometimes 50 per cent going to the foremen, 25 per cent to the workmen, and 25 per cent to the non-producing class, as clerks, etc., engaged in the general administration. All such systems are recognized to be in line with general welfare work rather than as furnishing a particular incentive towards intensive production. It is a maxim of the modern manager that a stimulus in the shape of reward should be immediate as affects the work and the payment, and stress has been laid upon the necessity of rewarding the workmen weekly so they may have visible evidence of the returns from their extra efforts by the weekly pay envelope. Bonus means incentive, and the art of management has demonstrated the necessity of coupling this with punishment for failure, the incentive pulling from the front and the punishment pushing from behind, as it were, in order to get the best efforts of the men.

The ancients knew of this principle as well as we, and both a heaven and a hell were coupled together in order to provide the necessary balance wheel to regulate the conduct of the human race. Various punishments have been applied to the men, such as disrating, fines, disciplinarian measures, and discharge. The writer believes that the system of fines, if it could be applied, would probably be the most effective punishment, but it would seem to be illegal and would probably not be sustained by the courts in a contest, and could not for that as well as for political reasons be used by the Government.

We have now reached that part of the disucussion of the bonus where the question of the stimulus provided through it may be examined into more in detail, and its effect upon the output of the shop more carefully considered. It has been shown in a previous paragraph that the first essential of shop management is to standardize the conditions in the shop so as to accommodate the point of the tool in the endeavor to maintain it operating at maximum rate throughout the working hours.

Let us suppose a shop so standardized that such maximum rate is attainable but dependent upon whether or not the cooperation of the workmen is obtained. If we suppose that a slackening on the part of the workmen to the ordinary output of the day-wage system would cause a similar slackening in the output of the tool, it would seem to be useless to expend extra money in obtaining such standard conditions unless the increased speed of the workmen should take advantage of it. A shop whose tool output is potentially three, but which is run by the workmen at the rate of one, when they could be speeded up by sufficient incentive to the rate three corresponding with that of the shop, would be entirely dependent for its efficiency as to whether or not the workmen were stimulated so as to bring about the maximum production attainable.

In order to standardize the conditions in a shop we have seen that a planning room with its large personnel has been added, in addition to the functional foremen and other assistants, the tool room and tool-grinding appliances systematized, the machinery speeded up and the belts kept in continuous order; if now the great expense necessary to add to the overhead cost of the shop be withstood in order

to bring about these facilities for the sake of introducing standard conditions, there might not be sufficient justification in making these expenditures unless this standardized shop were utilized to take full advantage of the standardized conditions.

Under the so-called military system of shop management the journeymen were largely engaged in doing their own managing, and the overhead charges were considerably less. With the overhead charges largely increased, as under scientific management, it is believed that the stimulus of the bonus is essential in order to offset this large overhead as well as to carry the production to the desired degree beyond what it was before. In 1912, the testimony of General Crozier showed that at the Watertown Arsenal "the cost of molding caster wheels for shop trucks had been reduced from $1.45 to $0.93, making a saving of $0.52 in this molding job, which is 35.8 per cent of what the cost had been, and the saving to the Government in making the things at this rate had been at the rate of $7.22 per day. The man's pay was increased from $3.28 to $4.44 a day, which was an increase of 35½ per cent. That was a bench job."

In another connection he testified that a certain job under day work cost $42.35. After a time study had been made of it the cost was reduced to $24.78, making a saving of $17.48, which was over 41 per cent of the original cost. The saving represented a sum of $9.94 a day to the Government. The man's pay was increased from $3.52 to $5.02, which was an increase of 42½ per cent.

The experience gathered from various sources as a result of the application of the Taylor shop system showed, it is believed, a saving of about 33 1/3 per cent in the cost of the work where it applied, with an increase in the pay of the workmen by about 33 1/3 per cent. Recently, when the new law suddenly stopped the application of the premium at Watertown Arsenal, the time to do a job of work went up to two and one-half or three and one-half times what it was under the premium. The shop had standardized conditions before and after the premium and had the benefit of standard times derived from the time study, the only difference being in the payment of a premium as a stimulus to the men.

It would seem, therefore, that the loss in efficiency on account of the lack of a premium is greater than was the gain through the installation of the system in the first place. If such is a fair deduction, it would seem inevitable that the Taylor mechanisms would have to be reduced or eliminated to a permissible extent so as to reduce the managing personnel and equipment affecting overhead charges to an amount commensurate with the altered circumstances.

The writer is convinced from this showing, as well as from the returns of American industrial managers from all sources, that the premium in itself is the most essential factor in the Taylor, as well as every other system, where the great progress of this country has been reflected in increased efficiency and output. The common fame surrounding American industry, which is typical of American life, and which is so often cited as being infinitely superior to the conditions in foreign countries, has become so firmly established in the minds of the public at large that it is hard to realize there is so much doubt as to the reasons for it.

If the history of increased efficiency of production be carefully examined, it will be found that high wages have traveled along step by step in the same proportion, and these high wages have been brought about more through the application of the premium than anything else. It may be easy to obtain assent to the general proposition that hope of reward has always been a greater incentive than fear of punishment, and that the premium system has been the greatest stimulus in American industry. Our national life, our general intelligence and progress as a people, and our wage rates would be more comparable to those existing in European countries were it not for such stimulus. There has been organized opposition to every new element of progress that has been developed, but time has been the cure, and will be, no doubt, in the future as in the past.

THE PSYCHOLOGY OF MANAGEMENT.

It may be interesting to mention at this juncture that the principles which have been introduced into modern industrial management have been along the lines true to the teachings of psychology, and the efficiency engineers have adopted these necessary measures in order to take account of human nature in shop production and to surround the individual with conditions that take advantage of his nervous system as an ally instead of an enemy. The qualities of the mind and the reactions of the body are kept in full view in those practices which have led to time study, motion study, bonus, repeat work, functional performance of work, the division of labor, and specialization.

The teachings of mental philosophy have demonstrated the number of subdivisions of action taking place in mind and body, between the beginning and end of an act. The signal is received from external sources by one of the sensory organs, and transmitted to the brain as information; second, this information is associated with previous similar information and brought into relation with past experience and assimilated as knowledge, through a mental process; and third, the product is transformed into action by the occurrence of the nervous discharge, or escape of a current downwards into the muscles and other internal organs, producing a muscular movement called reaction, which, in the case of a workman, produces motions, which are the subject of motion study, and which motions produce work.

The particular application of the bonus upon the functions of the mind, in performing a shop operation upon a piece of work, occurs during the period while the mind is considering the various elements comprising the job, and the amount of consideration necessary to be given to any particular case is what may be called the mental process, and the time taken to go through the mental process depends upon various considerations and involves an amount of time which cannot be measured by time study, but can be reduced to a minimum through the application of principles which take advantage of the operations of the mind. The brain contains the principal nerve centers, and the upper centers comprise the work of the hemispheres which are called upon to perform those processes in which consider-

ation and discrimination are involved whenever a distinct intellectual operation accompanies the reaction. The lower brain centers perform those ordinary functions of the mind which are called subconscious or automatic functions, such as the control of digestion, blood circulation, etc., as well as that other class of actions that have become automatic or semi-automatic through habit. That is to say, in other words, the mental process above described takes place when the highest nerve centers of the brain are called upon to perform throughout a cycle, or chain of operations, leading up to an action.

This process is accompanied by a material change in the psychological substance of the brain, resulting in an impress in a physical way of sufficient duration to cause a similar process, if repeated, to occur more easily the second time, and so on *ad infinitum.* If the same process be thus repeated a great number of times, the same reaction tends to occur automatically and becomes independent of reasoning through the higher centers, its control being turned over to the charge of the lower nerve centers, where the process thereafter occurs automatically through habit. It is the psychology of an acquired habit to produce a similar discharge from the brain through a pathway by which the current from incoming signals always tends to escape. If the thing is repeated often enough, the habit becomes more confirmed, and the similar action is produced automatically and taken care of by the lower brain centers without the exercising of an intellectual operation by the hemispheres. The more actions on the part of the human body which can be turned over to the lower centers by habit, the freer the hemispheres will become to deal with new operations not comprised within the realm of habit.

In order, therefore, to reduce an operation of the body, as a shop operation, to a minimum in point of time, it is best to eliminate the mental process by reducing it to a matter of habit. Habit, as illustrated by William James, professor of psychology at Harvard University, in his work on "Psychology," is likened in its effect to a garment, which, after having been worn a certain length of time, clings to the shape of the body better than when new, through a change in the tissue giving it a new habit of cohesion. A great number of illustrations may be made of the effect of habit upon inanimate matter, as well as upon animate matter and upon the mind, the nervous system of which is plastic and susceptible to the effect of repeated action.

If you fold a newspaper once, or a number of times, it will tend to fold itself thereafter. With the human mind a habit of action diminishes the conscious attention on the part of the brain with which the act is performed. The example of a driverless mule hauling ore from the ore bank to the furnace by a certain road may be cited, where through force of habit acquired through a repetition in hauling load after load from the one place to the other, the mule only needs to be started from the ore bank towards the furnace; he plods his habit-beaten way, reaches his destination, turns round and backs up his cart to the right spot, without a word of instruction, and after the operative trips the load and gives the mule a word, he returns unaccompanied to the ore bank, turns round, and backs up for his new load without additional instruction.

Mr. Gantt, in his book on "Work, Wages and Profits," has insisted upon the importance of training workmen to regular and fixed habits of work, and this principle has been extended not only by him but by the leading modern managers to the instruction of workmen of all kinds, not only in how to perform their work but also in the principles of constancy in their habits of work. This principle is illustrated in the functional instructor of the Taylor system, the one who instructs the functional bosses as well as the one who instructs the workmen by means of personal illustration, as well as the instruction cards, in how to attain the unit time and the habit of maintaining it.

Advantage is taken here of the psychological principle occurring in human nature, from which it is known that in youth below twenty the personal habits of the individual become fixed, such as in motion, gesture, pronunciation, dress, etc. It is said that most people at the age of thirty have acquired habits that have set like plaster, which will never soften again.

The mental process, or thinking time, which occurs in a workman's head before committing an act or performing work, depends upon the time necessary to go through a complicated reaction. If the reaction were simple, as between the time a man steps on your toe and the time you withdraw your foot, the mental process would be automatic and a minimum. In a complicated reaction, however, the mental process goes through a chain of operations in which each step depends upon a separate act of attention by the mind, depending upon the number of elements comprised in the act. Each movement in a job of work is tested by a separate intellectual operation before undertaken or, after performed, before proceeding to the next. The mind assimilates, hesitates, discriminates, compares, chooses, revokes, rejects, reconsiders, etc., and the next movement is discharged in the way in which this deliberation has been gone through with.

In a new job of work, it is quite possible that between each motion there is a recurrence in the selective process of the mind, resulting on the whole in the consumption of a considerable element of time in going through the various performances. If, however, a job is repeated sufficiently often to form a habit, it is only necessary to start the workmen on the first step of the chain of movements and the others automatically follow and are handled by the lower brain centers without the recurrence of the mental process in the intellectual operations as before.

Herein lies the advantage in subdividing work so that each man will only have a single operation, or the fewest possible number of operations to perform. On the other hand, in the case of an all-round workman who should undertake to build a boat in which one day he may be sawing the lumber, another day bending the keel, another day planing the planking, another day erecting the frames and rib-bands and so on, following one different kind of operation after another to the completion of the boat, it may be seen that the lack of repeat work and the great number of different kinds of work must necessarily result not only in waste motion between one kind of work and another, but also in a mental process between undertaking one portion and another of the work.

While a first-class journeyman can attain a sufficient degree of excellence to turn out a first-class job in quality, yet the additional time consumed due to his performing such a great variety of operations is inevitable and shows in the extra cost of the work.

To carry this idea to its extreme application, let us take a battleship, for instance, and undertake to build it in a shipyard that has never before undertaken a job of that kind. Let us assume that 5,000 individuals are to be employed in its construction and that none of them have previously performed the exact work necessary in this case, although all of them may have done similar work in other forms of construction sufficiently to belong to the proper shipbuilding trades. Lack of practice and of habit will inevitably bring about the necessity on the part of each individual of studying his work and undertaking a series of new mental processes in connection with every feature of the work. It is sure that any combination of shipbuilding trades and professions could ultimately turn out the requisite quality of workmanship, but the main difference between the output of such an organization as compared with that done by another shipyard, trained to the habit of building vessels of that size and kind, would be very appreciable and inevitable in the matter of time and cost.

It is in this particular feature in connection with complicated work that the instruction card in modern management has been valuable, for the reason that the experience of high-class mechanics is rendered available and is transferred through the instruction card direct to the mechanic on the job, and the result is to eliminate a large proportion of the mental process which would otherwise be employed by the workman before commencing each act of work. It can easily be seen that if the unit time has already been attained, after the same or a similar job has been reduced to its lowest terms, the workman in following his instructions is relieved of all the mental processes which would otherwise be necessary for him to begin the job. The instruction card undertakes to describe in detail "what to do" and "how to do it," and it is so administered through the routing system and timing of work as to tell also "when to do it." It is true that even with such a job there still remains a residue of mental processes between each operation, but these are sought to be reduced to a minimum through the concentration of the attention of the workman by means of the bonus.

The attention is another element dealt with in psychology, and in this as in other qualities of the mind it is necessary to captivate it and utilize it to the furtherance of the purposes of management. All individuals are subject to a wandering of the attention, as is well known in everyone's experience. One may listen to a sermon and yet not realize what is being said owing to its lack of interest, but his mind may wander continually upon other things all the while. The attention may become so dispersed that one may stare at vacancy, all the sounds and actions of the world fall upon the ears unheard, and a certain lethargy may exist which is hard to shake off, although a certain consciousness of the state of mind in which one exists may be present all the time. There are few people who do not at times

thus surrender to the empty passing of time, as may be recalled by the remark of the old farmer who said that at his home "We sometimes set and think, and sometimes we just set."

The concentration of attention is peculiar to a genius, out of whose mind there is a continual growth of new thoughts, new ideas, new projects, new developments. Most people, however, do not get far away from their schoolboy days when mind-wandering in the classroom and subsequently in ordinary life is the rule. The attention, in order to become focused upon a work, must have a motive, else it will be involuntary and lack concentration. To quote from James:—"First, to strengthen attention in children who care nothing for the subject they are studying and let their wits go wool-gathering. The interest here must be 'derived' from something that the teacher associates with the task, a reward or a punishment if nothing less internal comes to mind. If a topic awakens no spontaneous attention, it must borrow an interest from elsewhere."

I would like to insist here that Mr. James is not an efficiency engineer, and is not interested in scientific management so far as I know, else he might be accused of writing a book in order to bolster up, in certain places, the teachings of modern industrial managers. On the contrary, the efficiency engineers have rather gone into the field of psychology, as well as of political economy, and the stimulus used in management has been in all ways that are coincident with the best utilization of the qualities of human nature and of the mind in order to bring about not only maximum application but also maximum conservation of human energy. Of conservation of energy more will be said later.

James says further, "Voluntary attention is always derived; we never make an effort to attend to an object except for the sake of some remote interest which the effort will serve."

Herein lies the application of the principle of the bonus. In securing the necessary concentration of the workman upon a job through the introduction of stimulus by the incentive of more pay, which is the strongest available motive of derived voluntary interest, the stimulus used, operating to concentrate the attention, brings into play the higher brain centers and best reduces the mental process to a minimum. The mental process of uncultivated people or of untrained workmen is naturally long. Fatigue and intoxication have a tendency to lengthen the mental process, depending upon the degree. Practice and concentration both have the effect of shortening the mental process; and the quality of the signal, whether simple or varied, introducing the external information to the brain through the senses, has the effect of varying the mental process, depending upon the nature of it. These are all among the teachings of psychology.

Also, it is well established that in work where the mental process is constantly called upon to go through a process of chain operations as described above, especially in connection with new work, which calls into play continually the upper brain centers, the effect brings about very great fatigue if indulged in to any particular extent. Herein lies another feature of scientific management, as it is well

known that efficiency engineers have insisted that the mechanisms employed by them in the modern shop have been aimed particularly to eliminate fatigue; and the measures undertaken have applied not only to the shortening up and elimination of the mental processes and reducing them to a minimum, but also of eliminating all lost motion and uncomfortable attitudes of the body in order to accommodate both mind and body to the maximum extent.

It has become a tenet of modern engineers that high efficiency travels along the same path with minimum fatigue. The opponents of some of the elements of efficiency management have claimed, on the contrary, that the mechanisms strain the workman and push him to his maximum physical limit. All evidences at hand go to show that this was merely a claim growing out of the representations of the leaders among the workmen which has never materialized as far as anybody has been able to demonstrate from the returns of the manufacturing establishments throughout the country. In so far as time study, motion study, and the instruction card have the effect of eliminating express volitional deliberation from the mental processes of the workman, they are essentially valuable *per se* and tend to a minimum of time and cost in production, as well as to a minimum of effort and fatigue on the part of the workman. There is no getting away from these conclusions.

It would thus seem incomprehensible that a law should now stand against such a valuable asset in the practice of industrial management under the Government, which it does in forbidding the application of this branch of science because it happens to form one element in a system of management obnoxious to that class of our population who have, on the whole, profited most through the consequent simplification of their work and the high wages brought about by the methods which involved these considerations.

This attitude may be accounted for in a jocular way by a citation of another quotation from James on the subject of the action of the hemisphere and the lower brain centers. Of the latter he says:—"In the frog many acts devolve wholly on the lower centers; in the bird fewer; in the rodent fewer still; in the dog very few indeed; and in apes and men hardly any at all."

In other places he as well as other authors show, and we all know it to be true, that the highly educated modern efficiency engineer has trained his hemispheres, which are the chief seat of association of one ideal with another, of memory and of the mental process, to form a habit of thinking by concentrated attention and by developing the highest welfare mechanisms and philosophy available in man; whereas in the lower classes, that have not been educated to the same extent, the lower brain centers are called more into play, which may account in part for the conclusions of some of the opponents of the modern ideals in industrial management.

Although the study of mental philosophy is a clue to those qualities of the mind showing the inevitable inducements of incentive introduced by the bonus, there are many countervailing considerations surrounding the policies of the workman through the creeds of his unions and labor organizations, and it has been

demonstrated in practice that the full benefits of such an inducement have not been available save as the exception to the rule and such exceptions have been enjoyed only through the revolutionary changes in the mental attitude of employer and employee alike, whereby the former has been induced to extend the fair deal to the workmen not only in the form of uncut piece, or premium rates, but also through welfare and sociological betterment work sufficiently to secure the friendly cooperation and even the enthusiasm of the worker superinduced by the prior example in these particulars set by the management.

The very complication surrounding an analysis of all the elements going to make up the sum total of the collective cooperation and enthusiasm of the whole personnel of a plant, embodying as it does the sharp division and clash of interests involved, furnishes a motive that the future alone will be able to develop to the highest attainable degree. When that is done, the merits of the case will in all probability be more generally recognized, and it may then be more clearly perceived that, upon psychological grounds, time study and the bonus are freighted with good for the working man in particular, and, coupled with political economy, possess great potentialities of benefit to workers, employers and society at large, as set forth in the next chapter.

POLITICAL ECONOMY IN MANAGEMENT.

As an inducement to the worker and to the labor organizations to favor the merit and efficiency basis of payment with increased output, the efficiency engineers have heretofore in their literature held out the economic advantages of intensive production, setting forth the facts as they are shown under the principles of political economy, that increased production brings necessarily in its train a decrease in the cost of manufactured articles available for the uses of the public at large, including employer and employee alike, whereby the workmen themselves, being the largest element of society, profit mostly by such increase in the available necessities and even the luxuries of life. These teachings have all been true enough, although it is doubted if they have reached the worker owing to his lack of education in political economy, advancing theories he cannot see, and also owing to his more immediate interest in the fate of his job, as influenced by the principle of over-production, which he can very well see.

In the early stages of industry, before money had become the general basis of exchange, the producer of corn traded that commodity with the producer of pork and of other commodities in exchange for a sufficient quantity of these to supply him with the necessary articles of food and equipment with which to supply his needs. As a growth out of this condition, it became a custom at one time for individual producers to attempt to grow all the different kinds of commodities which they needed to carry forward their business and methods of living. The writer remembers, within the short span of two score years, a plantation owner in the south who grew his own corn, his own wheat, his own oats, his own sugar cane, his own melons, his own garden truck, his own apples, peaches, plums, figs, mulber-

ries, grapes; grew and cured his own tobacco, raised and slaughtered his own hogs, and cured his own bacon; smoked his own hams, raised his own cattle and horses, made his own lye, his own soap, kept his own hives, gathered his own honey, and made his own wax candles; grew his own firewood, and sawed his own lumber; made his own whiskey; manufactured with his own loom the cloth for the clothing of the family and the hands on the place; and grew cotton on the side to sell for the money necessary to purchase his other commodities.

Such a situation seems very far removed indeed from the specialization in production due to the economic changes in the division of labor at the present day, but such condition was the setting for the wonderful recollections and intimate associations with all the phases of this sort of production on my grandfather's plantation during my early boyhood days. Industry in this country to-day has been very far removed from the above methods, due to the vast increase of output through the division of labor where each individual by specialization has been able greatly to increase production through the additional dexterity acquired in the repetition of a single class of work. This increase in production has brought to both manufacturer and worker a corresponding increase in earnings, and with these earnings they are able to exchange upon a money basis the product of their output for the commodities they need which are the products of the labor of other specialized trades, so that now their purchasing power is vastly increased, and they may thus acquire through such purchase a greater quantity of other commodities than ever could have been manufactured by the worker under the waste motions and general inefficiency which are known to surround the conditions of varied and quantitative production.

Intensive production has thus in its wake brought increased earnings to the worker, decreased cost of commodities to society at large, and the ultimate economic effect has actually been marvelous in this country in bettering the condition of workmen of all classes in spite of any theories of over-production and in spite of all fear and hatred of abundance by employers and employees alike—fear of reducing the price of manufactured articles and wages below the point of profit. Although it is perfectly clear that in any particular line of business the danger of over-production has existed temporarily and rival concerns have had to limit their output at times, yet on the whole experience has shown that even in unique cases of over-production the effect has been rather to educate the tastes of additional customers to the use of such articles through their decreased cost, so that the demand has ultimately been extended to cover the breach between profit and cost, and both manufacturers and employees, as well as the general public, have profited by the increase in commodities.

It has now become an axiom of political economy that "Work breeds work." A process of readjustment has constantly taken place in this country *pari passu* with the increase in wealth, in production, in efficiency, in wages, and in the general uplifting of the conditions of life of the workmen throughout the land, whereby today an American workman enjoys more comforts and luxuries than did a king in the days of early English history of only a few hundred years back.

"In the days of Queen Elizabeth, the small capitalists and trades people and nobility lived in houses with mud floors and rushes for carpets. They used meat only two or three times a week, and they ate that meat with their fingers; and two changes of linen and two suits of clothes and a single finger ring were considered signs of opulence. * * * Do you know the wife of a single successful engineer, or a successful skilled machinist, or a good carpenter, or ten-hour-a-day lumberman—do you know the wife of one such, who lives in a house with a mud floor, and has meat on her table only twice a week, and eats that meat with her fingers, and owns only two changes of personal and bed linen, and wears only a single finger ring? * * * I venture to say there is not a mechanic in the United States, who is not living better than the small capitalists and trades people and titled courtiers of Queen Elizabeth's day. My farm manager and the men who work under him live better today than the nobility of Queen Elizabeth's court." (Quotation from *Illustrated Sunday Magazine,* "The New Wage Level after the War," by Agnes C. Laut.)

The great increases in the transportation facilities of the country and the enlargement of the markets for the sale of any product have made possible the expansion of the above principles of exchange in commodities to the extent now enjoyed, as Adam Smith showed in 1776 in the earlier stages of the modern industrial era, that the benefits to be derived from the division of labor are limited by the extent of the market. Professor Taussig says in his "Principles of Economics":—

"The village cobbler will turn out no more shoes than it is possible to dispose of within the economic area he can reach. To divide the work of shoe-making between the cutter, the stitcher, the heeler, the laster is not feasible unless as many shoes can be marketed as the combined labor of all will produce. A modern shoe factory, with its elaborate machinery and highly developed division of labor, turns out thousands of pairs of shoes daily. These shoes can find their purchasers only in a large population reached from the central source of supply."

As an object lesson of high wages incident to intensive production and shorter hours, the following scale of wages is said to have been issued in May, 1916, by the Bureau of Labor, Washington:—

Bricklayers, 87.5 cents an hour.
Carpenters, 65 cents an hour.
Hoisting engineers, 75 cents an hour.
Hod carriers, 50 cents an hour.
Wiremen, 75 cents an hour.
Painters, 70 cents an hour.
Plasterers, 87.5 cents an hour.
Plumbers, 75 cents an hour.
Stone cutters, 70 cents an hour.
Iron workers, 70 cents an hour.
Linotype workers, 83.3 cents an hour.

Most of these trades work on an 8-hour basis. Of course these wages are somewhat abnormal owing to the war, but such wages have been in vogue on the

Pacific Coast during many years past, and the rates throughout the country have been advancing all the time with the increase in wealth of the country and the efficiency of production.

That intensive production and high wages go hand in hand is shown in an editorial in London *Engineering,* January 26, 1917, from which the following is a quotation:—

"The whole history of industry has established the fact that reduction in the cost of manufacture and its selling price tend to increase the demand and stimulate its use; without exception the ultimate result has been increased demand for labour, higher earnings, and greater comfort for the working classes. It is true that revolutionary changes resulting from inventions which have suddenly multiplied many times the production of any given manufacture have involved momentarily dislocation of employment. Therein is some justification for the fear of the worker; but this does not apply to evolutionary changes, and in any event, when one takes the long view, for which we contend, there is the possibility of clearer judgment, and therefore a readier acceptance of the truth that machinery must increase earnings and reduce the cost of living. * * *

"That this extension of mechanical power has been not only beneficial in reducing the cost of living, but in augmenting earnings, Dr. Hunter had no difficulty in establishing. He showed that the artisan's real wages, taking into account the cost of living, were 100 per cent greater than in the years immediately following the Napoleonic era, while agricultural workers were 77 per cent better off; indeed, at no time in the history of England would the conditions of the workmen compare with those of the present. Taking 1850 as a starting point, the years 1865-9 showed an increase of 10 per cent, 1875-9 an increase of 30 per cent, 1885-9 an increase of 50 per cent, and the years 1895-9 an increase of 90 per cent; in fifty years the real wage was quite doubled. Again, on the other side of the balance sheet, there is the fact that in 1881 food and drink were 39 per cent higher than at the beginning of this century. In European countries generally real wages per hour worked are 20 to 30 per cent lower than in this country (England), notwithstanding that the working week is of from 58 to 60 hours, instead of 54 as in this country. Miners' wages on the Continent are about 40 to 50 per cent less."

Such are the basic considerations growing out of the division of labor as taught by political economy. Extending this principle to the shop is nothing new on the part of modern efficiency engineers, and indeed one might say that the word "functional," which has been used in management, only expresses the idea of specialization along the lines that have heretofore been understood and practiced a long time ago. The following is quoted from Adam Smith's "Wealth of Nations," 1776:—

"This great increase of the quantity of work which, in consequence of the division of labor, the same number of people are capable of performing, is owing

to three different circumstances: First, to the increase of dexterity in every particular workman; secondly, to the saving of the time which is commonly lost in passing from one species of work to another; and lastly, to the invention of a great number of machines which facilitate and abridge labor, and enable one man to do the work of many."

The initial and most celebrated example of specialization, or functional work, is the old and familiar citation occurring in the manufacture of pins of long ago, of Adam Smith, which is quoted as follows, from the same work and date as above:—

"To take an example, therefore, from a very trifling manufacture; but one in which the division of labour has been very often taken notice of, the trade of the pin-maker; a workman not educated to this business (which the division of labour has rendered a distinct trade), nor acquainted with the use of the machinery employed in it (to the invention of which the same division of labour has probably given occasion), could scarce, perhaps, with his utmost industry, make one pin a day, and certainly could not make twenty. But the way in which this business is now carried on, not only the whole work is a peculiar trade, but it is divided into a number of branches, of which the greater part are likewise peculiar trades. One man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head: to make the head requires two or three distinct operations; to put it on is a peculiar business; to whiten the pins is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed by distinct hands, though in others the same man will perform two or three of them.

"I have seen a small manufactory of this kind where ten men only were employed, and where some of them consequently performed two or three distinct operations. But though they were very poor, and therefore but indifferently accommodated with the necessary machinery, they could, when they exerted themselves, make among them about twelve pounds of pins in a day. There are in a pound upwards of four thousand pins of a middling size. Those ten persons, therefore, could make among them upwards of forty-eight thousand pins in a day. Each person, therefore, making a tenth part of forty-eight thousand pins, might be considered as making four thousand eight hundred pins in a day. But if they had all wrought separately and independently, and without any of them having been educated to this peculiar business, they certainly could not each of them have made twenty, perhaps not one pin in a day; that is, certainly, not the two hundred and fortieth, perhaps not the four thousand eight hundredth part of what they are at present capable of performing, in consequence of a proper division and combination of their different operations."

It is thus seen that the extension of the principle of specialization to the division of work in a machine shop and the application of the same to the functional

foremen of the Taylor system contains nothing new in principle, but is only an extension of its application.

The same may be said of time study, and the writings of Charles Babbage, an early British efficiency engineer, in "Economy of Machinery and Manufacture," 1832, demonstrate this in his discussion of the use of the watch in timing shop operations and of instructions covering such observations, to be covered by a skeleton form. His instructions are quoted as follows:—

"In filling up the answers which require numbers, some care should be taken. For instance, if the observer stands with his watch in his hand before a person heading a pin, the workman will almost certainly increase his speed, and the estimate will be too large. * * * The number of operations performed in a given time may be frequently ascertained when the workman is quite unconscious that any person is observing him. Thus the sound made by the motion of a loom may enable the observer to count the number of strokes per minute, even though he is outside the building in which it is contained."

The *American Machinist* of November, 1912, contained a discussion on "The Present State of the Art of Management," in which quotations from Smith and Babbage are presented along partly similar lines, the same having been included in a report of the Committee of the American Society of Mechanical Engineers heretofore alluded to, which changed the name "Scientific Management" to "Labor-Saving Management." The burden of that committee's report was not only to find a new name to substitute for "Scientific Management" but also to enunciate "the new element in management" which the experiments surrounding Mr. Taylor's work were held to have brought forth. The committee's discovery of a new element was as unfortunate as its discovery of a new name, as no new element existed, but this was the finding as quoted from the language of the board:—

"It appears, however, that another principle is the basic one in the rise of industry. It is the transference of skill. The transference of skill from the inventor or designer to the power-driven mechanism brought about the industrial revolution from handicraft to manufacture. * * * Setting these against the underlying principle of the transference of skill, we conceive the prominent element in present-day industrial management to be: The mental attitude that consciously applies the transference of skill to all the activities of industry."

The idea conveyed in the discussion upon the transference of skill was applied by the introduction of labor-saving machinery to take the place of the old handicraft work. The case of the shoemaker is the most fitting, where in olden times an entire shoe was made by one man from start to finish. This man, in order to produce at a profit-yielding rate, was an expert. To-day, shoes are made by a great variety of machinery among the four hundred different machines manufactured

by the United Shoe Machinery Company, of Beverly, Massachusetts, and each machine performs a separate subdivision of the work on each shoe by an operative attached to each machine, which operative is not necessarily an expert mechanic but is of the ordinary class of workmen easily trained to do the repeat work of his machine, in which the machine has taken over the expert features of the work, leaving the operative only that portion which any man may be trained in a short time to perform, and which in certain cases is merely supervisory.

I think the illustration of the transference of skill to the shoe-making machinery of the United Shoe Machinery Company is the most exquisite example anywhere available, and if one should witness, as the writer has done, the work of that particular machine which stitches down the raw edges surrounding the button-holes, he will be able to realize more acutely than ever the full force of the meaning of transference of skill, as this machine, as well as a great number of other machines used in shoe-making, seems to possess almost human intelligence and a combination of human attributes in putting through its work with great accuracy and a high rate of speed.

While the pay of an operative is relatively much less than the old-time pay of the all-round man, yet it is an increase over what such automatic operative previously received. The all-round man has likewise increased his pay by being promoted into the planning room or thinking department, as under modern management the thinking department has been vastly enlarged in proportion to the consequent reduction in the actual work of handicraft. The transference of skill, therefore, from expert handicraft to machinery is not at all a new principle in management, as it is well known that this transfer has been taking place gradually throughout the entire history of economic development. There is another kind of transference of skill, namely, from the expert operative to the repeat work operative, which is no more new in principle than that to machinery. Any number of modern efficiency engineers have described it in different ways, but some one of them described it some years ago generally as follows. Expert work is that which has not been reduced to book and depends upon unusual dexterity acquired within the knowledge of the few. To reduce such work to standard work consists in analyzing it and describing it fully by a written instruction and teaching operatives generally how to perform it, so that they can acquire the dexterity of the expert either in performing the whole or in performing a suitable subdivision of the whole by a lower class man. This operation reduces work from expert to standard, and has the effect of transferring the skill of the expert operative to the repeat work operative.

There is nothing new in this excepting in the application and in the educational literature setting forth new descriptions of a process that has been going on in every class of industry all along from the very beginning. This is perfectly obvious to the writer, as it will be to everyone connected with any branch of industry. In the beginning of steel shipbuilding in this country nearly all the work covered by the specifications and the contract was expert work, subject to be investigated and

developed during the period of construction, very little being covered by cut-and-dried instructions in advance. Today all classes of this work have become so standardized that there is hardly any feature of it but what is covered by detail specifications at the time of the bids. This development in standardizing requirements, specifications and methods has developed gradually all along from the start and is as much an application of the same principle as in the development of shop management with its new rules reducing science and experiments to practice along the lines of political economy, psychology, humanity, the Bible, and every other aid that man could devise.

Even the extreme application of the division of labor in modern shops which is now being stressed as a new phase of scientific management and welfare work, in the adaptation to tasks of varying aptitudes and the careful analysis of the qualities of the personnel and the subdivision of the work among them so as to take care of the old as well as to place each man in that class of work where he is most fitted, is nothing more than a utilization of those principles of economics in the division of labor which have heretofore become well known, though the general application and extension of the principle is relatively modern.

THE ART OF CUTTING METALS.

This paper is now assuming such proportions that it will be necessary to limit the discussion to a mere outline of principles, but it would not seem fitting to omit a reference to the leading discoveries of Mr. Taylor on the art of cutting metals, since they form such a large proportion of the valuable science on which the production of a machine shop depends. I will therefore cite some of the leading features of the work as developed by that author, not for the purpose of illuminating the subject but only enough to excite the interest, it is hoped, of those who may not have followed the matter.

Mr. Taylor in 1880 found himself foreman of a machine shop of the Midvale Steel Company, where the machinists had combined and were turning out the usual agreed-upon quantity of daily output under piece work; and realizing that fact he sought to determine by experience just what output a man ought to turn out, so that he could combat the workmen's contentions. He expected his experiments to last six months, but they lasted altogether about twenty-six years, extending from that company to the Bethlehem Steel Company with his change of position between those two companies. In carrying on that work, more than ten special machines were fitted up for experimental purposes, between 30,000 and 50,000 recorded experiments were made and many others of which no record was kept, more than 800,000 pounds of steel and iron were cut up into chips with his experimental tools, more than 16,000 experiments were recorded in the Bethlehem Steel Company, and between $150,000 and $200,000 were spent upon the work.

With the first of these experiments it was discovered that a heavy stream of water poured directly upon the chip at the point where it is being removed from

the steel forging by the tool, would permit an increase in cutting speed, and, therefore, in the amount of work done of 40 per cent.

At Bethlehem, tests were continued to determine whether Mushet self-hardening steel was superior to Midvale self-hardening steel, and in the different processes of experimental heating the accidental discovery of modern high-speed tool steel was made. The self-hardening steels at that time were superior in cutting quality to the ordinary carbon-tool steels, but it appears no shop had utilized such superior quality for turning out more work, but only for cutting the harder grades of forgings to which the self-hardening steels were better adapted. The old-fashioned carbon steels were tempered by plunging into water after heating, whereas the self-hardening steels possessed the peculiar quality of retaining their hardness by cooling slowly in the air.

The new discovery was that tools made from chromium-tungsten steels when heated to the melting point and allowed to cool in the proper way would do from two to four times as much work as other tools, and that by adding a small quantity of vanadium the result was materially improved. The process of heat treatment was, first, the high-heat treatment, and second, the low-heat treatment. The high-heat treatment consisted of heating the tool slowly to 1,500° F.; rapidly from that temperature to just below the melting point; cooling fast to below the breaking-down point, that is, to 1,550°, or preferably to 1,150°; cooling either fast or slow from this point to the temperature of the air. The breaking-down point is that point between 1,550° and the melting point at which the tool will be injured, unless the temperature remains absolutely stationary, or continues to fall throughout the operation of cooling after it has once started. To avoid this the cooling is performed quickly throughout the dangerous range of temperatures. The second, or low-heat treatment, consisted in heating the tool, first, to a temperature below 1,240°, preferably to 1,150°, for a period of about 5 minutes; and second, cooling to the temperature of the air either rapidly or slowly.

Since the Taylor-White discovery—Mr. White being the principal assistant cooperating with Mr. Taylor on these experiments—modern high-speed tool steel has been further improved by adding additional quantities of chromium-tungsten, vanadium, and molybdenum; and the low-heat treatment has been dispensed with, as it has been found in experience not to be necessary. The tools become hot and cold within the lower ranges constantly in use, and without detriment. The results have been to increase the cutting speed, and therefore the amount of work done, in cutting a hard steel forging from a cutting speed of 6 feet per minute of the standard Jessop Carbon (tempered) steel, and 8½ feet of the Mushet (self-hardening) steel, to about 40 feet of the high-speed tool steel. On hard cast iron, the cutting speed was increased from about 15½ feet to 52 feet, bottom to top; and on medium steel forgings from about 16 feet to 99 feet. The increase in output per tool is in proportion to the speed, and added to that is the capacity of the high-speed tool to retain its shape throughout its cutting period between grindings, and thus avoid losses due to dullness.

The experiments were made to determine the best shapes of the tools, having in view both the cutting and regrinding properties, in which both elements were measured on the basis of maximum combined economy. Some of the Taylor standard tool shapes are shown on Plate 35. These tools are designed upon the following basis:—First, the necessity of leaving the forging or casting to be cut with a true and sufficiently smooth surface; second, removing the metal in the shortest time; third, the adoption of that shape of tool which shall do the largest amount of work with the minimum combined cost of grinding, forging, and tool steel; and lastly, ready adaptability to a large variety of work. The Tabor Manufacturing Company of Philadelphia have manufactured for sale two sizes of tool-grinders, designed by Mr. Taylor, which embody the shapes of tools resulting from these experiments. I understand the Sellers tool-grinders also embody similar results, presumably from the Sellers' connection with the Midvale Company, the experimental work leading to the two makes of machine having been probably more or less parallel. Perhaps someone may correct me if mistaken on this point.

The particular characteristic of the high-speed steel, wherein it differed from the former kinds, was not in that it was harder, but that it possessed the quality of maintaining its cutting edge sufficiently sharp and hard to cut steel even after its nose became red hot, and because in many cases it heats up the chip or shaving which it is cutting until the portions of the chip which are exposed to the friction of the tool become red hot. That is a double advantage over the former tools, since the former broke down at the cutting edge when it became hot, and secondly, with the new steel retaining its hardness when red hot, called red hardness, it attained the additional advantage over the chip by the latter becoming red hot, and consequently softer to cut.

Mr. Taylor found that the maximum cutting time of a tool before resharpening was one and one-half hours for best economy; Mr. Barth varies the rule to one and three-quarters hours. The regrinding comprises removing only a small portion of the tool, to which the Taylor shape is accommodated, and the tool service is so regulated as to be automatic and continuous in supply from the tool room, with a standardized tool-grinding department as heretofore described, in order to keep the work of cutting going continuously without interruption at the point of the tool.

A new departure was inaugurated in the method of testing tool steels, as before that time experimenters compared tools on the basis of the length of time before requiring grinding, or before being ruined. The writer remembers a series of experiments carried out on this basis made at one of the leading navy yards a short time before his incumbency, where a dozen different brands of carbon tool steel were tested by comparison throughout a period of a year or more by keeping a record of the performance of each tool upon different classes of work and the length of time the tools lasted before destruction. As a result of studying the records of these experiments, my conclusion was that the evidence showed no advantage possessed by one brand over another, as the results seemed to be wholly inconclusive. Obviously, Mr. Taylor has dissipated all false notions about the proper

method of testing tool steels, and he adopted a standard of comparison of a cutting speed in feet per minute which will cause the tool to be completely ruined after having been run for 20 minutes under uniform conditions.

The round-nose tool was, as is well known, the best for roughing work, the reason being that a curved edge removes a shaving which varies in thickness, the maximum being at the limit of feed and the minimum at the point of the tool. Only the tool with straight line cutting edge removes uniform thickness of shaving. With a curved roughing tool, that part of the cutting edge which does the finishing thins down the shaving at this point to such an extent as to insure the finishing part of the tool remaining sharp and uninjured, even though the main portion of the main cutting edge may have been ruined from over-heating, or some other cause. This insures a good and true finish of the work. Different tools are required for cutting hard and soft steel.

Upon Plate 35, Fig. 7, is reproduced one of Mr. Taylor's drawings showing a forging as it is cut by a round-nose roughing tool, in which the depth of cut, the feed, and the dimensions of the shaving are clearly indicated. In arranging the proper cut on any job, the speed, feed and depth of cut are to be determined. The experiments showed that the thickness of the shaving or the feed has a greater effect upon the cutting speed, while the depth of the cut has only comparatively small effect. In order to determine the speed, feed, and depth of cut, the problem was found to possess twelve elements, or variables, as follows:—

(*a*) The quality of the metal which is to be cut.

(*b*) The diameter of the work.

(*c*) The depth of the cut.

(*d*) The thickness of the shaving.

(*e*) The elasticity of the work and of the tool.

(*f*) The shape or contour of the cutting edge of the tool, together with its clearance and lip angles.

(*g*) The chemical composition of the steel from which the tool is made, and the heat treatment of the tool.

(*h*) Whether a copious stream of water, or other cooling medium, is used on the tool.

(*j*) The duration of the cut; *i. e.*, the time which a tool must last under pressure of the shaving without being reground.

(*k*) The pressure of the chip or shaving upon the tool.

(*l*) The changes of speed and feed possible in the lathe.

(*m*) The pulling and feeding power of the lathe.

The problem involved more unknown quantities than there were equations available, and it was solved by Mr. Barth, one of Mr. Taylor's assistants, who developed his almost inevitable slide rules, shown on Plate 36. These slide rules are exhibited in a paper by Mr. Barth, read before the American Society of Mechanical Engineers, December, 1903, Vol. XXV of the transactions. Fig. 1 of this plate is a slide rule embodying the main problem for determining a suitable

combination of speed, feed and depth of cut for a given diameter, or class of work. After these elements are determined, the time slide rule of Fig. 2 is used, in order to determine the time it will take the tools to do a given job for the sake of determining the task time for entering on the instruction card. For finishing work, or where the power element is immaterial, the question of feed and speed being paramount, the speed slide rule of Fig. 3 is used to determine the selection of a speed combination available on a particular machine. Fig. 4 shows the gear slide rule, which is used to limit the work to the strength of the gears, where power is involved in the cutting.

The problem of the belt was also worked out by Mr. Barth in this connection, and a belt slide rule was developed by him, shown on Fig. 5, for determining the size and tension of the belting necessary to convey the desired power under the proper conditions of efficiency. The problem of the belting was immense and involved a separate science of its own, which was investigated and standardized by Mr. Taylor and Mr. Barth and their collaborators. The first results of these experiments were published by Mr. Taylor in a paper entitled "Notes on Belting," read before the American Society of Mechanical Engineers, December, 1893, Vol. XV of the transactions, as a result of nine years' experiment at the works of the Midvale Steel Company. This paper was displaced, however, by a paper of Mr. Barth entitled "The Transmission of Power by Leather Belting," January, 1909, read before the American Society of Mechanical Engineers, the last-mentioned paper being pronounced by Mr. Taylor as the last word on leather belting.

It is not my intention to go further into the details of Mr. Barth's slide rules, but they have been placed merely in exhibit, as no paper on industrial management would be complete without them, and no machine shop of any size can afford to ignore them. However unpopular the Taylor system may have become among certain classes, at the same time the Barth slide rules have, during the last few years, crept into many machine shops through the back door, including some of the great shipyards, and are to be found among the drawer literature of the shop foremen who are endeavoring to secure the immense advantages to be derived from the results of a scientific work that is monumental in its character and revolutionary in its effect.

Some years ago I collected together a large proportion, if not all, of the literature covering this subject, and among it I find a catalogue issued by the Tabor Manufacturing Company of Philadelphia, which purports to have on sale the equipment embodying the results of the work of Messrs. Taylor, Barth, and other assistants, including the participation of Mr. Hathaway, I believe, as affects leather belting, as well as the Taylor tool shapes and tool grinders, including tool-room racks and arrangements, all worked out ready for application in any shop. This equipment is such as used in the Taylor system at the Watertown Arsenal and other plants, and while I have no brief or other connection in common with the Tabor Company, I wish merely to mention that anyone wishing further information on this subject cannot do better than to obtain it from the Tabor catalogue, which

sums it up in a way that would take a long time otherwise to gather together from his own personal observations.

Mr. Emerson is authority for the statement that the standardization of belt practice has increased the life of the belt by more than six fold, has reduced belt failures to one-sixth of what they were, and has decreased the annual cost of belting to less than one-seventh of what it was. I should like to make a few additional observations, however, upon the belt department, as I believe that in a particular shop it is necessary to limit the mechanisms and details to the needs of the shop rather than to install every feature of the experimental apparatus which was used to determine the science surrounding the belt. In this respect, it is like some of the mechanisms appertaining to the Taylor system of management. There is such a thing as going too far as if on a basis of perpetually continuing the experiments after the shop units have been determined, and the personnel educated so as to attain said units by new rules of thumb, based on the scientifically attained results, and by belt tensions grown familiar to the touch of the hand.

I believe there is no large shop with a sufficient amount of belting to justify it, which should not have the belt bench, belt-lacing machine, the tickler-record cabinet, etc. After a while, when the men become used to the paraphernalia and familiar with the attainable units of tension and with the methods of caring for belts, they will, to a large extent, discontinue of their own accord the constant use of the experimental apparatus and operation of it, retaining for the most part the knowledge attained through experience.

I gather that at the time this belting problem was first worked out by Mr. Taylor, leather belting was in much more general use than at the present day, and the problems surrounding it were a very much greater factor than now when most shops have introduced the motor drive, and in some of the modern shops leather belting exists only to a very minor extent. In some of the great shipyards the motor drive is almost exclusively used, except to a minor extent where a number of small machines are still driven from a line shaft through narrow belting. All of this belting falls within the class of small size thin belting which scientific analysis has best determined should be laced upon the ordinary wire belt-lacing machine such as most establishments possess, and the question of belt-lacing is at once correctly solved without further ado.

In a shop of this kind the proper tension and rules for care of belting may be determined from the literature on the subject, a tension spring and scales of the simplest kind improvised, and a repair gang employed to care for the belting outside of hours or otherwise, so as to avoid the stoppage of the machinery. All this can be done after a careful study of the question without very much belting equipment, but no well-regulated shop can afford to avoid accumulating all the existing information upon the subject and applying it to a sufficient extent, determinable from the circumstances in the case, to attain the desired results. Whoever operates a belt-driven shop to-day that has not gone into this question is temporizing with wastage.

In a different connection it might be added here that the question as to the advisability of driving shop machinery by motor is determinable from the efficiency of the motor under its shop load. A motor runs efficiently at full load, but inefficiently at half-load, or other fraction, the smaller the load the less the efficiency. The writer once set up a joiner shop designed by other hands, where four motors were purchased to drive four lathes, two 5-horse-power and two 3-horse-power. An analysis of the lathe load under test showed that one of these motors would drive the four lathes at somewhat under load of motor, and the arrangement was so modified. In this class of installation the motor is very likely to be underloaded under the average lathe output, and when some of the lathes in a group are thrown off the motor the operating load becomes very small and the inefficiency great. For small machinery, therefore, it is wise to consider, first, the belt drive through a line shaft, and the belt drive brings with it the problem of the belt. Otherwise, the motor drive brings with it the problem of designing the motor to operate at full power under average load, with a temporary overload high limit.

Some years ago the writer called Mr. Taylor's attention to an article in one of the current technical magazines describing steel belting, which was promised to eliminate leather belting and all belting troubles. Mr. Taylor remarked that he would believe it after he saw it done. Nothing of late has been heard from steel belting. At that time I also asked Mr. Taylor why Mr. Barth did not publish an interpretation of his slide rules so as to render them available without the necessity of employing Mr. Barth to install the whole system along with it at $35.00 per diem. He replied that the information could be dug out of his book if one took the time, but we both seemed to agree on my proposition that life is too short for such digging where one can get the slide rules. In the absence of such slide rules, however, it would seem immensely worth while to go and dig.

Mr. Taylor's experiments on equipment surrounding the point of the tool showed that the belting theretofore used was generally too light by one-half, that the machinery was not sufficiently strong to take the loads available under high-speed steels, and that the speeds of machines attainable were not sufficiently great. His conclusion was that after the shop had been modified to render the use of high-speed steel available within the range of the machinery, no well-regulated shop should ever use other than high-speed steel.

I wish now to point out in particular that the wonderful results attained by Mr. Taylor through his experimental work in the art of cutting metals have been derived from a careful study of the operation of the tool, in a machine in which the stop-watch was used to measure the time, and that this measure of the time is the great basis around which all the experiments were centered, the purpose being to secure those conditions which would permit of doing the work in the least time. It was in that particular that Mr. Taylor's experiments differed from those made by experimenters before his day. The stop-watch is an accurate measure of time, and possesses no qualities more objectionable than any other time measure. In my estimation the source of the greatest improvements in production which have

enabled the industries of this country to obtain their present high state of advancement has been the bonus, and next to that the study of the time to do a job whether through the stop-watch or whether through long-continued observation obtainable from shop records.

However that may be, time study was the basis of the greatest advancement in tool cutting in the world's history through the work of Mr. Taylor, and was the father of high-speed tool steel. I should like now to ask the question whether the existing prohibitive laws forbidding the Government to make with a stop-watch or other measuring device a time study of any job of any employee between the starting and completion thereof would or would not stand as a bar to any experimentation worth while on tool steels, for the sake of future improvement. And if such law had heretofore existed and Mr. Taylor had not made his experiments, could the Government ever have undertaken scientific experiments looking toward improvement in metal cutting with tool steel? The answer to these questions is obvious and may be supplied by each one for himself. In this connection the following quotation is taken from a paper by Messrs. Frank A. Vanderlip and Thomas A. Edison, in *The Engineering Magazine* of January, 1917:—

"It is because of this combined and united influence that the labor leaders, and particularly the labor politicians, were able to drive through the recent session of Congress the absurd and damaging 'riders' to appropriation bills prohibiting the payment of premiums and bonuses to the workers who will build our great new navy and all of the equipment and armaments for both the navy and army. This was a direct injustice to labor itself, as could have been clearly demonstrated had there been time enough for the work; but the labor leaders and the labor politicians had their way because they had organized and prepared for the purpose, and had shrewdly selected a presidential campaign as the appropriate time to force unwilling votes in their favor."

THE EMERSON SYSTEM.

The writer's files contain a collection of literature bearing upon the work of Mr. Harrington Emerson and his associates, which are the deductions from a publication entitled "Efficiency as a Basis for Operation and Wages," by that author published in *American Engineering,* including a half-dozen pamphlets descriptive of the principles involved, as issued by the Emerson Company, and certain other writings such as those of Charles D. Hine, from *Engineering Magazine,* and Hugo Diemer from *American Machinist.*

The Emerson system, as far as I am able to make it out, is in its sum and substance, as applied to the shop, the Taylor system, modified and elaborated in certain details; as, for instance, the Taylor "work board" becomes the Emerson "dispatch board"; the Taylor "rate" becomes the Emerson "schedule"; the Taylor "planning department" becomes the Emerson "dispatching department"; there is the same time study, bonus, task, routing, systematic material supply, belting and tools

departments, and the rest. The paper-work mechanism varies, I believe, in its details, and the Emerson wage payment plan is used instead of the Gantt, together with an efficiency rating of workmen by which premiums are said to be gradually, and not abruptly, diminished. The Emerson literature goes into the details of cost accounting along the lines of A. Hamilton Church, but more elaborated, whereas Mr. Taylor's system of management embodied the same general system in his practice, though he did not deal with it in his writings. Both, I think, probably followed after Mr. Church in the development of the machine-rate style of cost accounting, which is the essential measure of their work in the cost accounting features. Mr. Emerson's writings, however, have built up a series of new and descriptive definitions, over and above the shop system, which deal with the general questions of the larger phases of management such as would apply in a modern shipyard; for instance, where the work of the administration building deals with the output of a great number of shops.

In studying the Taylor system from the writings of Mr. Taylor, one is left at the end of the machine shop, so to speak. It is necessary to make a personal investigation in order to get Mr. Taylor's ideas with respect to compound management, involving the organization and administration of many shops. Mr. Emerson goes into the higher questions of administration and attempts to set a new definition of management as conveyed by the subdivisions under what he calls "Line and Staff Organization." The staff work is subdivided under four heads:—

1. A head of staff to look after the well-being of workmen—a welfare man, so to speak.

2. A head of staff to look after the equipment, consisting of structures, machines, tools, etc.

3. A head of staff to look after the materials, their purchase, issue and handling.

4. A head of staff to look after methods and conditions, which includes standards, records, and accounting.

These heads of service I take to be in the nature of efficiency engineers, and Mr. Hugo Diemer adds to Mr. Emerson's program a chief of staff over and above these four, who, I think, would become the efficiency engineer of the plant with the other four as assistants. These men, of course, in a shipyard would take their offices in the administration building, as that is where such work would be done. The line organization is said to comprise the executive branch of the management, consisting of the manager, superintendents, foremen, etc., in immediate charge of the execution of the work. These are men of action who execute the orders and instructions, which orders and instructions are formulated by the staff in their respective divisions, said staff having no executive control but only advisory, their functions being rather judicial, as Mr. Delano Hine sets forth. In other words, the idea conveyed is that the line is the executive branch and the staff the thinking department, such as one may conceive along parallel lines to the General Staff of the German Army, which illustration has frequently been worked overtime by the

authors of various systems with a view to convincing others in a doubtful case. These writers assume the division between line and staff in all branches of the Army and the Navy, including industrial, to be like the staff of a military commander.

There is a great deal of fog about distinctions of line and staff not only in the services but also in the literature relating to industrial management. I should advise anyone desiring to make a clear illustration, to avoid comparisons upon the basis of line and staff, unless accompanied by the clearest possible description of the particular application involved. Naval writers have endeavored to prove schemes of reorganization by reference to the wonderful results of the German General Army Staff in the War of 1870, which is now a back number, generally in order to further something different which they desired. The essence embodied in the line and staff idea is the case of a military commander and his personal staff, which usually includes mostly line officers. The functions of the staff are purely advisory, but are sometimes used as messengers to subordinate commanders on the field of battle. In administration, however, in the Navy, the Staff Corps are staff as respects military operations, though they do assume line functions in fighting the guns during battle. In their own sphere, however, they are executives, and in industrial work they are mainly line and, in a few posts of duty, staff. That is to say, the line performs staff functions and the staff perform line functions, by any analysis of duties.

In industrial management, line and staff distinctions are likewise apt to be confused, and I shall endeavor to apply my own description of what I conceive to be lines of demarcation of the Emerson line and staff divisions, in such a way as to make it entirely clear. Broadly speaking, an industrial establishment with a line organization is such as existed before the advent of the modern efficiency engineer, and the staff may well be taken to signify the addition of an efficiency engineer as head of a new department embodying all which that term conveys in the new order of things. The line and staff argument, therefore, is a plea for the addition of an efficiency engineer, or four or more of them, under the name of staff, and indicates a place for them in the modern establishment. At least one of the great shipyards has employed with advantage, during several years past, a production engineer, exercising the functions lately called that of efficiency engineer, and others may well profit by the example if they have not already done so. It may be observed here that the Taylor system, with its efficiency engineers, might as truly be classified as a line and staff arrangement perhaps as well as any other.

Further along in this paper, under the heading of "Organization," the writer has presented an outline of what he considers a desirable addition to the meaning of the word "staff," as distinguished from "line," in industrial management. It separates the engineering and design work in the administration building at shipyards from among the line functions and classifies them with the staff, to the extent that the naval architect and the chief engineer have no administrative control beyond the confines of their respective offices, but must approach the foremen,

who execute their plans through the works manager save only in a cooperative way, which latter is practiced to the greatest possible extent. That is to say, the foremen may not vary one iota from the plans and instructions they receive except by authority of the works manager, and the naval architect and chief engineer cannot make a single alteration in their plans and instructions after they have been approved and placed for execution in the shipyard, save through the works manager. All authority is blocked in both directions save through and by the works manager, which has the effect of truing up the work of all parties concerned and of locating responsibilities.

A few years ago a certain large shipyard adopted this plan, and, to cite a prominent instance, found that their foremen had been manufacturing a great number of a certain class of fittings for vessels in the past in accordance with the approved plans, but that other foremen, not finding said fittings suitable for use on the vessel, stowed them away without reference; and, the fact not having been reported back to the draughting office, the process was repeated over and over again for different ships, involving each time the loss of valuable fittings save for the purposes of scrap. The adoption of a strict and tight rule as outlined above is not a theory but has been found to be desirable in practice, the reasons for which are sufficiently ample to be convincing.

There is something more, however, to the Emerson system, which maintains a business organizataion with an active personnel of collaborators, and with propaganda and literature commanding the field of the current press. Mr. Emerson has stressed his twelve principles of management, namely:—

1. Ideals.
2. Common-sense.
3. Competent counsel.
4. Discipline.
5. The fair deal.
6. Efficiency reward.
7. Records, reliable, immediate and adequate.
8. Planning and dispatching.
9. Standards and schedules.
10. Standardized conditions.
11. Standardized operations.
12. Written standard-practice instructions.

These are merely descriptive terms which grew out of those conditions surrounding the time study and the bonus and become absorbed therein, as a matter of course. The golden rule, profitable ethics, and the Ten Commandments, might be added without particular advantage or detriment.

This point of the discussion raises the question of how best to install modern management in an unorganized shop; whether to employ a firm of efficiency engineers, who have had experience in a railroad shop and other branches of manage-

ment, to apply the system in works foreign to their experience, such as shipyards, for instance. Efficiency engineers have argued that their principles are applicable to any kind of a shop if undertaken by them, whether they ever knew anything previously about the business or not.

I think it is essential that the parties installing a system in any plant should be thoroughly familiar with the work in that plant, and that they should be also familiar with the details of the system installed. Certain it is that they have to become familiar with it in order to run it after installation. It is a cooperative business, therefore, and it would seem the quickest and surest way is for the management of a concern to study up the details of the system to be installed, and then thereafter to employ an efficiency engineer to install it under the control of the management. By the time it is installed the management will be so familiar with its operations as to be able to continue it without the assistance of the efficiency engineer, and will be able to limit the applications of shop mechanisms on the part of the efficiency engineer, also, so as to fit it properly to the case in hand; and after the installation of it they can further reduce and eliminate the mechanisms as advisable, while maintaining the shop standards and units, determined through the experimental operation of said mechanisms.

Some establishments have undertaken to study the question and introduce these mechanisms, as installed by their own subordinates, and have profited greatly thereby. While this is quite possible and desirable, at the same time it would seem to me advisable, at a certain period when conditions are right, to bring in an efficiency expert and let him apply his knowledge in attaining the maximum conditions of output, after which the management may rest easy that the best results attainable have been acquired. For those outside the Government who can see their way clear to apply the time study and the bonus, there would be a comforting effect if Mr. Barth could run his slide rules through the establishment and pronounce the results satisfactory. In this review of systems, I am not in the business on the part of anyone, or advocating the cause of anybody whatsoever, but am merely placing my estimate of what the literature, the observation, and the practice of the subject have brought forth from my point of view.

THE VICKERS SYSTEM.

Some years ago the Vickers system, so-called from the Vickers shipyard in England, was introduced at the Norfolk Navy Yard by the Navy Department, as a result of internal navy politics and the clash of opinions within the service and among the efficiency engineers at that time. There was great question as to what the Vickers system was, and in the partisanship which was developed it was styled "a bluff," "a set of absurd orders," on the part of one of the leading partisans of the Taylor system, of "only words" on the part of the most prominent of the efficiency engineers, and "an enigma" on the part of various people who desired to find out what it really meant. One of the high officials responsible for the installa-

tion of it gave a description of it before the Naval Committee, which, though cloudy, conveyed a trace of system which led to further inquiries.

In view of the general curiosity existing at the time, the *American Machinist* took measures to obtain a report made by a qualified engineer as a result of an investigation at the works of Messrs. Vickers, Ltd., at Barrow-in-Furness, and the result was published in the *American Machinist,* April 11, 1912. That report showed the Barrow works is divided into three broad sections, namely, shop, engine, and gun mounting, of which the two latter constitute the engineering department. The Halsey premium plan in general was used only in the machinist, or metal-working trades, called the engineering trades in England. In the shipyard department straight piece work was used on plate, shape and smithery work, including riveters, caulkers, drillers, etc. Only machinists and fitters of this department were paid on the premium plan. For work on the premium system, time study and rate-setting were employed. There was no planning department under that name, but the elements of a planning office existed nevertheless in the use of a rate-fixing office, a carefully developed material and order system, a "tool designing" office, general stores or stock-rooms, time-keeping office, and a central progress office. The "tool designing" office determined the jigs, fixtures, and tools necessary for the different jobs, in the way of planning work, embodying obviously the control of the tool room and that portion of the planning work in this connection done in the planning department and by a gang boss.

There was the usual draughting room organization, and an independent inspection department, in charge of a chief inspector. This inspection department is necessitated by the bonus system, for reasons heretofore previously disclosed, and the chief inspector performs another function incidental to government contract work at a shipyard, which consists in managing the inspection business in general not only primarily in behalf of the shipbuilding company but also is responsible for submitting all work to government inspectors after he is satisfied through his own force of subinspectors that everything is satisfactory.

Here American shipyards, having the premium system, may take another note to great advantage. The only thing novel in the Vickers system, and differing in principle from the Taylor system, lies in the use of a work-tracing system by the central progress office in lieu of the automatic paper work of the Taylor system. In fact it may be recognized that the Vickers system, in work where the premium applied, is essentially the equivalent of the Taylor system with that modification, the shipyard department being piece work, as in other shipyards. The work of the progress section was to supply additional personnel for the purpose of independently following up work, especially large parts, throughout its course in the shops, as a supplement to the efforts of the works manager and the shop foremen in that connection. That is to say, these progress men comprise additional superintendents in recognition of the generally established modern practice, through whatever system, that the complex conditions of modern manufacturing require the attention of a greater number of superintendents than in the past. The progress men followed

the work throughout its course from beginning to end and collaborated with the foremen and with other officials in supplying information in the right place at the right time and pressure to the advancing of the work as the circumstances warranted.

The writer made inquiry of Mr. Taylor in 1912 as to the Vickers system, and was informed by him that the Vickers Company had sent four men to acquire information about the methods of the Bethlehem Steel Company while he was there in 1900. In this connection, the following is a quotation from a letter from Mr. Taylor to me, dated August, 1912:—

"Four men from the Vickers Company came to the Bethlehem Company while I was there, and stayed from two to three weeks, and I helped them all that I could."

Further than that Mr. Taylor was unable to account for the Vickers system. It may be interesting to add in this connection that it is very well known that the introduction of premium systems and time study in British shops followed their introduction in this country, and the honors lie between Mr. Halsey and Mr. Taylor in that connection.

As stated above, the Navy Department, in 1912, inaugurated a system, called the Vickers system, at the Norfolk Navy Yard, comprising the following subdivisions of effort in management, namely, a central planning section (including an estimating section), a progress section, and an examiners' section. It did not include the time study or bonus, which is obviously the soul of the Vickers system, but did include the progress section of that system. The central planning section, not having existed in the case of the Vickers system, is identified as being essentially the planning department of the Taylor system. The examiners' section I was unable to trace, as to its origin, after endeavoring to do so through the *American Machinist*. It seems that no such section is known in the Vickers system. The duties specified under this section consisted of the detail routing in the shops and of securing best machine tool speeds and results, including other desirable methods for shop standardization. This is easily recognized as being the function allotted to the speed boss in the main, and the gang boss and planning department in part, under the Taylor system.

The Norfolk system at one time contemplated, I know, a material clearing house, for the assembly of machine shop and foundry output for inspection and assembly purposes, but this was never developed up to the latter part of 1913, since which time I have not been in touch with that yard, but I doubt if anything important came of it. In other places where this element of the Vickers system was imitated, the experience may be somewhat different, especially at the Philadelphia navy yard; but at the Fore River Shipbuilding Corporation such a clearing house was built and used for a year or two, and thereafter abandoned as unsuitable.

At the Philadelphia yard this system was extended and the following subdi-

visions were established, namely, a planning and estimating section, a material clearing house, a progress section, and an examiner's section. In this application the material clearing house has been given the prominence of a separate phase in management, following the lines set forth in the testimony appearing before the House Naval Committee regarding the Vickers system, although the report of the *American Machinist* did not mention it. I am unable to indicate just how this system was used, or whether it was used, and in what application, by the Vickers Company. It can easily be seen, however, that in certain classes of work, as in machine shop and foundry, and machinery-erecting shop, such an arrangement might be found very efficacious. At the same time, the limitations of such a system would depend entirely upon whether or not the material clearing house was in the immediate vicinity forming an incidental link between the output of the shops and the erection of the machinery, or whether or not the machinery needed to be stored inside for some length of time before being used. In a plant where such an arrangement would fit, it is seen that the progress section would furnish a connecting link between two points, one the planning section and the other the material clearing house.

In this connection it is assumed that the Taylor shop-paper-work mechanisms have been displaced by the progress section and that the planning section has systematized its work for labor and materials, job orders, plans, etc., as far as can be foreseen definitely from the viewpoint of the planning office. After the work starts forward from the planning office and until it reaches its destination in the material clearing house, the progress section is to supplement the ordinary style of follow-up management and keep fully advised at all times of the progress of each job as it goes forward in the shops, thereby constituting in its own composition the necessary feelers and tentacles of the management so as to permit the latter to be in many places at one time, which is the function of the mechanisms of systematization under the Taylor system, or under any system where complete following up is carried out as it should be.

The progress men, therefore, have three positions from which to take points of view covering the work:—First, from its start at the planning office; second, from the points of assembly at the material clearing house; and third, en route between the two places. These progress men are thus enabled to go from one place to the other and to take an inventory and an assembled view from all sides of the course of operations in a particular job and in all the jobs, and in this way be able to apply a very much closer supervision over work than possible under the old style of management.

This feature of material clearing house has been adopted in principle at the Watertown Arsenal, where Colonel Wheeler introduced a method of his own, so I believe, of assembling parts of a job in shelves built for the purpose at a certain convenient place in the machine shop. This feature enabled the management to know by visible evidence whenever a job was completed in the shop and ready for assembly, and a casual inspection during the progress of a job would show which

parts were lacking and thereby furnish information found of value in that connection.

Fig. 1, Plate 37, shows an assembly chart of a job as used at the Watertown Arsenal under the Taylor system. For convenience, this chart is reproduced from an article by Fred H. Colvin, describing the Watertown system in the *American Machinist* of September 12, 1912. This chart is considered a valuable illustration of the method of breaking a job up into its component parts, upon the principle of scientific management, where everything is broken up into its elements before the next action is taken. The chart shows a number assigned to each part, by a convenient mnemonic numbering system, whereby an abbreviation is used to designate each part upon the job cards, inspection cards, and all other paper work affecting the job in its course through the shop up to the point of assembly in the shelves, where shelves are so used, or otherwise. It is obvious that an examination of the assembled parts at any time, in connection with the assembly chart, will convey information of value in connection with the assembly. The writer has exhibited the chart in this connection so as to illustrate a feature considered of value in connection with the so-called Vickers system, but it will also illustrate a valuable principle which might be used in any shop where systematization is desired, under whatever accompanying conditions.

As before stated, I do not think it wise to copy practices from one shop into another shop unless careful investigation should show that it fully applies, and the question as to whether or not a material clearing house, or point of assembly, is desirable, will depend upon the local conditions. At the Fore River Shipbuilding Corporation the material clearing house was found to be out of the way of the regular course of the finished product, and the point of assembling machinery was within the regular assembly rooms and all assembling was found to be more economical if directed to the actual points rather than to a side station, which was out of the beaten track.

I can conceive, however, that in the Philadelphia yard, especially in the machine-shop and foundry work, where the progress section supplies the necessary feelers and tentacles of the management in one department in tracing its work through the machine shop and foundry of a different department, it ought to be found of great value. Other shops elsewhere, however, situated differently, need not take anything for granted on that account. To sum up, the Vickers system might be found very suitable for machine-shop and foundry work, especially with time study and bonus, since the progress section supplies a larger number of additional foremen or their equivalent, which has been found necessary in modern management. In discussing the Vickers system at the navy yards, Mr. Taylor in a letter to me of August 26, 1912, stated among other things, of which there is quoted only a part, as follows:—

"As to your question about Vickers, there is very little known about the Vickers system in this country now. The Vickers system is merely words. * * * I do not think any attention need be paid for it for no Vickers system will ever be introduced in any of our navy yards."

There was much partisanship developed around this matter at the time, however, and allowing for that and taking all elements of value derived from other sources, I think it can be fairly said that the progress section of the Vickers system, and the material clearing house in certain particular applications, can be studied and imitated with value under certain conditions. The Fore River Shipbuilding Corporation, in connection with its now defunct material clearing house, had a force of progress men called strikers attached to the personal services of the foremen, and these likewise disappeared for the most part with the central clearing house. However, it is believed that the conditions under which the progress section as operated at the Philadelphia navy yard, surrounded by the high degree of systematization which has been introduced there, forms the best example available under which the progress section has been applied.

Finally, with respect to the Vickers system, it would seem that no system in our navy yards is entitled to such name unless it should have the time study and the bonus any more than it would be entitled to be called the Taylor system unless it possessed those two elements, even though the other details of systematization were the same. The Vickers system having time study and bonus as its basis, the same as the Taylor system, is more entitled to be called the Taylor system than any system without the time study, and the bonus is entitled to be called the Vickers system. If every system varying in details were entitled to be called by a separate name, there would be the Bethlehem system and the Fore River system, each of which differs in details from the other as well as from the Taylor system and the Vickers system; but I can only see two large classes of subdivision as between these systems, one of which applies the bonus and the other does not, but only applies systematization.

Shops operated without systematization are liable to become the victims of concerted eye service, as in the case of the navy yard tin shop heretofore cited as coming under my observation, in which 75 per cent of the apparent effort was lost motion. With systematization this lost motion would be eliminated as a result of such follow-up work and measures as would be thereby available. Industrial engineers a few years ago, when advocating scientific management with time study and bonus, gave a bad name to systematization as such; everyone advocating a cause leans as far over on the side of partisanship as will benefit his arguments, but systematization possesses a high claim to consideration for its own sake, there is no doubt, even though the bonus be not applied. No shop can afford not to be systematized and reduced to its lowest terms of waste effort and lost motion, through careful observation, if not through more definite measures.

There was a class of efficiency engineers who, on another phase of the question, even went so far as to represent that systematization comprising functional management and automatic paper mechanisms were of greater importance *per se* than the question of possessing men of ability in the management. The effect obviously was to over-stress the importance of shop mechanisms. Such an argument is too one-sided and too obviously biased to carry conviction, since nothing can take

the place of ability in the personality of the manager in whose hands the whole mechanisms of management are but the tentacles and feelers, as illustrated by Messrs. Church and Alford in their paper published in the current press a few years ago. Every works manager must possess instrumentalities which will permit his presence to be extended to a great number of places at the same time, and shop mechanisms, including cost returns, are the necessary means by which this is accomplished. Men of ability and administrative mechanisms are both absolutely essential, and the most important element lies in the personnel, as in every other phase of human endeavor. Ability on the part of the works manager and his collaborators in the administration building is more important than any shop measures or returns, if it should become necessary to determine as between the two. Of that I am sure there will be accord among those not interested in advancing any particular system of management.

OTHER CONSIDERATIONS AFFECTING SHOP MANAGEMENT IN GENERAL.

In a complex organization, such as a shipyard or a factory, the committee, or board system, has been found to be of very great value in modern management. Mr. Charles U. Carpenter in his "Profit-Making Management" first brought out and accentuated the advantages of such an arrangement. He believed in committees formed of the management and of the leading heads of offices to insure cooperation, to supplement system in management so that the heads of a concern, though they cannot see everything, can come very near knowing everything or at least be in a position to scent danger, locate it, and eradicate its cause promptly. Through such cooperation, each member of the committee is brought to feel that the work of the whole is his product, which secures his cooperation. Such committees should act in an advisory capacity as to promotions, final authority being vested in the superintendents. He believes further in subsidiary committees within the shop, as well as committees for conducting the management.

I have cited Mr. Carpenter's work as it was among the first to advance this subject in connection with modern organizations, although as a matter of fact the board system is as old as the hills, but its use has only recently been extended as a means of securing the acute control of the daily work in a large plant. The advantages of the committee system have been recognized and applied in a great number of plants, and in recent years the practice has been widely extended in certain establishments though not so much in others. Even the Navy Department and the navy yards have greatly profited in late years through the use of this system, and the great shipyards likewise. In one shipyard the committee system is at a minimum; in another at a maximum. In nearly all there are committees in connection with the employment, rating and discharge of labor. In one great shipyard there is a committee on management that has a daily meeting to discuss the current business, and this committee determines the premiums and bonus of foremen and leading men.

There is a tri-weekly conference between the superintendents and the foremen to discuss all ways and means in connection with the work in progress in which all have an interest. There are additional meetings between the works managers, superintendents, and foremen whenever an occasion arises involving those called to be present. There is a committee on safety; a committee on suggestions; a committee to run the cooperative store; a special committee on premiums; a welfare committee; a committee on discharges, to investigate complaints; a committee on apprentices; a committee on the yard lunchroom; a band and glee club committee; a committee on the clubhouse, and sub-committees of club members upon all the different branches of athletics partaken of by the personnel of the establishment. There is a sick-benefit committee and a committee on fire department. Altogether, there are two hundred and fifty men among the managers, superintendents, foremen and workmen, who are members of these committees. At these committees all subjects are discussed, and everyone made a party thereto participates in a way to secure his intense and immediate interest. Everyone has a right to be heard and has an equal voice in the discussions, subject of course to the usual reservations.

Many heads thus put together are wiser than one, especially in a complex organization, and it requires cooperation and united effort on the part of the superintendents in order to gather together by presence and voice information relative to the work, in addition to that available through the mechanisms of shop systematization, to enable the manager to direct the work in a way so that all details will be planned ahead and thus coordinated with each other without lost motion at their points of contact. Whoever operates a complex organization today who has not fully developed his committee system would do well to investigate the subject further and profit by its application to whatever extent warranted, and this, as in everything else, should receive a scientific analysis beforehand with modifications determinable through experience. H. P. Gillette says:—

"Perfect coordination involves the working of each man to his capacity all the time. This necessitates not only the organization of gangs of just the right size but the prompt arrival of standard supplies and materials, and freedom from breakdowns of plant. An examination of almost any piece of construction work in progress will disclose the fact that most of the men spend a considerable portion of their time waiting either for somebody else to do something or for materials to arrive, before they can proceed. The cause is improper coordination of the work. One gang may have too many men and therefore may be able to work considerably faster than another, and be continually catching up with it. They will then adopt a slower pace, keep seemingly busy, and manage to kill a large percentage of their working time. These delays are chargeable to lack of coordination, although a careful inspection of the work may seem to indicate that everything is going smoothly. A job can look smooth and at the same time be so badly coordinated as to be uneconomical."

The conferences of foremen serve to coordinate work in which the operations of several foremen are involved at one point or other.

The principle of doctrine in management is worthy of mention in connection with the committee system. The rôle of doctrine finds its amplest field of application probably in naval warfare where, least of all, predetermined actions can be anticipated and covered by regulations and orders, so as to secure the right movement in every contingency. A commander-in-chief cannot foresee all the dispositions of force at the moment of battle, nor all the changes occurring throughout an action. Hence the laws, regulations and general orders must be supplemented by a discussion of principles and contingencies in council with his leading and other subordinate heads through whom action is effected. The chief is thereby enabled to so convey his policies to the body of executives within his coordinated purview that these subordinates may be able to determine for themselves the action which the commander-in-chief would employ for any given set of conditions. It is in this manner that a fleet of vessels becomes indoctrinated with the policies of the commander-in-chief.

The means of indoctrination are the supplemental explanations, teachings and discussions carried on in intimate conference with this body of subordinates in which all contingencies are provided for. The effect of indoctrination is to convey to the understanding of such subordinates the line of action which the commander-in-chief would employ under any set of circumstances. It is not possible, of course, to foresee every contingency, but the ground is covered as far as possible, and thereby all existing means of transmission of requirements is affected to an extent not possible with the ordinary means available without doctrine. In fact, in naval warfare, the strategists have estimated its effect to be of very great and leading value in the administration of a fleet.

The same principle applies in law where statutes are made to cover every foreseen contingency, but there are so many human actions that it is not always possible to fit each under a statute without searching through the realm of the common law for a previous decision covering an exactly parallel instance. Hence the need of courts and lawyers, and even they do not suffice to cover the whole field as new questions and new applications arise constantly, and so the Supreme Court must be invoked in order to lay down a new rule in virgin territory to fit a new action not recognizable to others under any statute or previous decision. The theories of the law furnish the courts of last resort with doctrines to guide their action in such new cases, which is called the policy of the law, and is determinable from the rules enjoining that decision from which the best results would flow for the good of the country.

So likewise in industrial management, the principle of doctrine is applicable, though of course in a more restricted field. Through systematization, adequate records, and administrative instructions, the whole field of operations can be more nearly covered in an industrial plant than in the two instances above cited, but there remains a large territory where lack of harmony among the various execu-

tive functionaries subject to coordinated effort may exist, and therein lies the value of doctrine whereby the management may convey through the committee system its policies into the whole body of officials and workers in the plant, and such indoctrination is the more essential depending upon the complexity of organization and administration of the plant. Even in a small plant it is indispensable.

Competition is another element which should be developed to the maximum extent as a principle in industrial management. It is a well-known fact that where two ships, such as the Connecticut and Louisiana, were built by competition between a navy yard and a private shipyard, as to time and cost, these vessels were produced in much quicker time and at less cost than any previous vessels not in competition. These things are very well known and are attested by all who are informed upon the subject. It is not always that competition in the large can be brought to bear as in the above case, but the principle can be introduced into almost all classes of work through the introduction of standard jobs, absolutely definite and limited by a phrase or formula or designation denoting a "work equivalent" which does not vary from place to place. Workmen at one plant can thus be brought to compete with previous results attained at another plant or at another place in the same plant. One of the most apt illustrations of this principle that I have seen is in a paper in the *American Magazine,* by Mr. Charles M. Schwab, as follows:—

"Once when I was with Mr. Carnegie I had a mill manager who was finely educated, thoroughly capable and master of every detail of the business. But he seemed unable to inspire his men to do their best. 'How is it that a man as able as you,' I asked him one day, 'cannot make this mill turn out what it should?' 'I don't know,' he replied, 'I have coaxed the men; I have pushed them; I have sworn at them. I have done everything in my power. Yet they will not produce.' It was near the end of the day; in a few minutes the night force would come on duty. I turned to a workman who was standing beside one of the red-mouthed furnaces and asked him for a piece of chalk. 'How many heats has your shift made to-day?' I queried. 'Six,' he replied. I chalked a big '6' on the floor, and then passed along without another word. When the night shift came in they saw the '6' and asked about it. 'The big boss was in here to-day,' said the day men. 'He asked us how many heats we had made, and we told him six. He chalked it down.' The next morning I passed through the same mill. I saw that the '6' had been rubbed out and a big '7' written instead. The night shift had announced itself. That night I went back. The '7' had been erased, and a '10' swaggered in its place. The day force recognized no superiors. Thus a fine competition was started and it went on until this mill, formerly the poorest producer, was turning out more than any other mill in the plant."

In 1903 the writer utilized the principle of competition to great advantage in converting the army transport Grant into the dredger Chinook at the Mare Island

Navy Yard. The surrounding circumstances were utilized to incite the workmen with enthusiasm through competition. Before that time, throughout the Spanish War and subsequently, a great number of army transports and shipping on the Pacific Coast had been a lucrative source of contract work in which the private shipyards at San Francisco held a monopoly on the Pacific Coast. The Mare Island yard had been called on to submit bids on previous occasions but was never awarded a vessel, which, considering the bids, was believed to have been determined through politics rather than on merit. In this case the bids were $285,000 and $265,000 by the two leading San Francisco yards, that of Mare Island yard having been $225,000, subsequently raised to $235,000 through a readjustment and re-submission of bids. The Mare Island workmen had previously accumulated complaints of not having been given any of such work and did not expect to get this job as on previous similar occasions. When, however, it was awarded, the writer being temporarily in charge, though not having made the estimates, of the Construction Department, which had control of all but $18,000 worth of this work, the foremen and workmen were appealed to to make a record since, once for all, they had been given the opportunity to do what they had so long wanted to do, the motive being to influence the bringing of future similar work to the yard.

I dare say there was never displayed at that yard greater enthusiasm than in ripping that ship apart and binding her together again in the new form, and workmen never cooperated with greater zeal and good will than on that ship. The work was done in record time, with a total saving under the estimates of $59,000, although, but for the intervention of a countervailing policy, a saving of $100,000 was in sight, based upon the foremen's estimates after probably 90 odd per cent of the work had been completed. These results were due to the enthusiasm and cooperation of the personnel, and demonstrated fully to the writer that men are more effective in management than mechanisms. To finish the story of the Grant, several months after the work was completed there was a grand parade of workmen, officials and politicians to celebrate the showing made on that vessel, a model of which headed the parade, that was followed by the Senator, the Congressmen, naval officials, and others at the yard, all of which was evidence of the motive utilized in inspiring the enthusiasm of the workmen through the principle of competition.

The exception principle has been applied to modern management, which is a doctrine developed through experience whereby in a complex organization the manager has been shorn of all details and routine with which the old-time one-horse manager filled up his time. This doctrine is merely an authoritative notice to present day managers that they are no longer expected to bury their heads behind a multitude of routine papers, or lose themselves in a mass of details, or be caught engaged in pursuing some particular pet hobby occurring among the minor industries of the plant.

By force of the momentum of past practice, managers have no doubt felt it necessary to adhere to previous customs that prevailed in the day when employers

regarded efficient managers and a burden of details as inseparable. The modern doctrine serves to give notice that managers may still be efficient and yet divest themselves of these details. Not only that but the literature surrounding management has related stories showing how the one-man manager of a small concern failed and became a nervous wreck while trying to manage a modern concern on the same lines. By the exception principle the manager of to-day is authoritatively advised by those best qualified to give testimony that the details of management should be distributed among the assistants to the manager all along down the line, and that only certain questions arising in the department of each should be brought before the next higher authority for action. The condition is analogous to that of the old-time foreman who has been divested of the control of a multitude of details and this work subdivided among a great number of shop bosses, whose work likewise has by the exception principle been subdivided and distributed among their assistants. It is therefore said that the manager should deal only with condensed summaries of work and of costs, sufficient to form a flowing record of current events, such as is presented by progress curves, progress sheets, and other exhibits that can be read and evaluated at a glance. Authority has likewise been subdivided, and each head held responsible for that subdivision of the work assigned. The manager therefore can distribute all work devolving on him, as if sublet by contract, to whichever one of the subordinates is most fitting. He can then control the work through individuals among the subordinates and thus be able to convey his presence throughout the entire establishment and make it felt at whatever place pressure is needed to be applied, of which the condensed summaries in his office are an index; and while he is thus shorn and limited in respect to routine papers, he has the more time to go into any detail occurring worth while, which he would not have were he not liberated from the mass of papers that managers felt it incumbent upon them to occupy themselves with in days gone by.

With all due respect to the theories of the exception principle, it is believed there can be no fixed rules to fit the personal equation in the volume and complexity of the organization. Each one requires a dispensation fitting to its own particular case, but it is certain that in complex management the manager must divest himself of the routine details and supply himself with sensitive and adequate flowing records, and operate mainly through his subordinates. The exception principle is not correctly applied until that stage is reached where the manager may be absent for a day or a month in a complex concern without being missed. In this connection, the rôle of doctrine in management will have a bearing, as previously explained.

I had expected to exhibit a number of flowing records, such as are used in various branches of the work of an industrial plant, but so much has already been said that a mere reference will be deemed sufficient in order not to prolong this paper. Anyone reading this may recall an example which could be cited. In shipbuilding, a progress curve constitutes a flowing record, which conveys at a glance

information affecting the progress of the work. Any kind of work can be thus analyzed by transforming the features under examination in the form of a curve or in the form of a diagram or a table. Shipbuilders make a pictured diagram of the plating of a vessel, and by assigning different colors for the different months build up a flowing as well as a permanent record of the installation of the plates with respect to time.

So also with other parts of the vessel where a current analysis is desirable. In the foundry there may be a progress sheet, such as is used in the Taylor system, showing the exact location, status and degree of completion of every job, which can be evaluated at a glance. So likewise with the progress sheet covering work in the machine shop. The workboard is in a sense a flowing record, and Plate 38 shows a photograph of a planning board such as was used at the Boston Navy Yard a few years ago. Such boards are used in the planning department to hold job cards and other records, that serve as a visible analysis of outstanding jobs which may be evaluated at a glance at any time. The shop workboards possess a similar bearing and the shop bosses are enabled to determine action which is thus made self-evident without delay Workboards, or dispatch boards, are used in various shops in connection with premium job card work, but may be used in any class of work whether with job cards and bonus system, or not. Workboards have been used at navy yards to cover men on board a vessel, not under the premium system, which form an analysis valuable to the superintendent so that he can see at all times what men and what work are going forward.

The writer remembers a time when there was no such visible evidence and where, in the absence of the same, there was room for an immense amount of waste time, as it is important for a superintendent to know whether or not the workmen are properly engaged in the absence of some such record. On the transport Grant, as cited above, the writer erected the first workboard that he ever heard of on board that vessel at the beginning of her conversion, which consisted of a number of sheets of paper erected at the entrance where the names of the men were posted when going on board at the beginning of work hours. This was a crude workboard indeed, but I estimated that the fact of such records would have a psychological effect upon the minds of the men which would impress them with the belief that the management knew they were on board, and had some unknown and indefinable knowledge of what they were doing. I have no doubt that record bore fruit in the output.

There was another purpose at hand, however, as I improvised a temporary scheme of flowing records whereby I could have a daily report from the foremen, giving the numbers of men employed in the various shops and on board the various ships. I was only temporarily in charge and had no means of instituting permanent reforms, and there were no returns which showed where the total number of men were being utilized, but such information was so scattered about among the ordinary accounts and returns that there was no summation of it in any one place. In other words, there was no condensed summary and no flowing record

conveying the information. About the same time an incident occurred showing the value of such records, which was in connection with work on the transport Lawton at Mare Island at the same time. One such report from a foreman showed fifty-odd men accredited as being on board the Lawton the previous day. I had just been aboard the Lawton and knew that work had been finished the day before. Upon sending for the foreman, he reiterated his claim that the men were physically on board that vessel the day before, although I knew and he knew, and he knew that I knew, that not a single one of these men had been aboard the vessel upon the day in question. After the interview he returned to his office, and the next day voluntarily he submitted a request to lay off fifty-odd men for lack of work.

I do not wish to bring up the question as to incentives operating upon navy yard foremen or to insist upon a discussion as to whether their interests are parallel to those of the Government, but I do wish to say that a flowing record is absolutely essential in order not to lose the major part of control of the whole work, and I subsequently had reason to realize that the Taylor workboard admirably supplied the need I had previously felt in that connection.

The workboard can be subdivided in any number of ways. The columns may be listed by shops, by trades, or by machines, and applied to any group of elements. There is no complex work but what should be broken up into its parts and fitted into a workboard or progress curve, or progress sheet, or some other form of condensed flowing record, and a little ingenuity will suffice to supply the needs in any important connection. In 1908-09 the writer devised a flowing record at the New York Navy Yard covering repair work upon the various naval vessels under his control, in which a separate large sheet was devoted to each vessel and separate columns to each job order, and the costs were entered under each and a balance struck daily. Once a month the foremen were required to compare their cost returns with those in the office books, and, for the first time, so I was told, the foremen were brought to time and had difficulties at the end of the month in squaring their books with the flowing record. Prior thereto they had managed to put the chief clerk of the Construction Department on the defensive, as the records were not sufficiently complete to indicate who was in error, but in the face of the flowing record the tables were turned and the chief clerk at that yard has never gotten over expressing his gratification at the event. This record was mainly of use in furnishing current information to the management as to how the costs were running, which enabled all measures to be taken to bring those costs within the proper bounds, which I will say was done in connection with every vessel over which this control was extended.

Mr. Emerson lays stress upon the necessity of cardinal principle No. 7, "Records, reliable, immediate, and adequate," and in other connections he has laid stress upon the importance of proper cost accounting systems, and therein I think lies one of his strong points which cannot be too greatly emphasized in connection with management. Cost accounting is the main instrument by which management is

rendered effective, and flowing records of the same are more necessary and valuable than in any other connection, although the parallel mechanisms of organization and those of shop methods are necessary accompaniments, almost but not quite equal in degree of importance.

Before quitting this chapter, I desire to mention certain other important considerations involved in management which need not be elaborated, but only mentioned in passing. In a complex industry such as a shipyard, the item of transportation is one of the big factors, in which there is the opportunity for loss unless the whole transportation problem has been broken up into its elements and scientifically investigated, lost motions removed, and the problem bound together again at its lowest terms. There are an infinite number of permutations and combinations in this problem, it is frequently of vast proportions, it is expensive, and I dare say in a great number of plants furnishes the best field for savings as a result of scientific investigation and analysis.

In connection with transportation occurs the problem of efficient storage and supply of materials, the location of the proper storehouses, the quantity of materials to be carried in stock, their routes and channels of supply, and the efficiency of their purchase. All these are subject to analysis and improvement, especially considering that usually the work in the shops is a dependent sequence upon the supply of materials and the latter must be made as completely subservient to the point of the tool as any other element inside the shop.

The supply of materials is indeed a very important problem and depends upon whether the plant is situated on the Pacific Coast or in the east near the base of supplies, or whether it is a small plant and needs to carry only a small stock, or whether it is a navy yard that carries millions of dollars' worth of supplies in the storehouse. In the latter case the maintenance of a material stock in some cases is no problem at all, as it may be located near New York, and may carry stock in greater proportions than at other similar places. However, at a smaller plant, or one dealing in specialized materials, or one where the margin of capital available for stock is small, a stock balance sheet becomes of greater importance, and in Plate 29 is exhibited a method of keeping a "Balance of Stores." An examination of the four columns will indicate the methods whereby the balances are struck as they occur, and the sheet becomes a flowing record from which the needs as to stores are determinable automatically or at a glance. This sheet is such as used at the Watertown Arsenal under the Taylor system, and published in Mr. Colvin's article in the *American Machinist,* September, 1912.

To mention finally, but to perform first, the arrangement of buildings, transportation facilities, machinery, and other plant accessories must be given that careful consideration and analysis necessary in the first layout, and in any subsequent readjustment. A plant already established upon theoretical lines, or an old plant not readjusted to modern conditions, is subject to modifications incidental to experience with improvements made in systematizing the plant and bringing it under the best economic conditions. As the economics of a plant are important, the systems

should be bent and accommodated to short-cut methods, and machines moved, modified or scrapped, and buildings rearranged, readjusted and demolished, as all of these are secondary to the important developments in eliminating lost motions of past practice, for the reason that the time and current labor costs are of preponderating value and the savings attainable have usually more than justified discarding obsolete equipment, methods and arrangements as soon as shown by an adequate analysis to be desirable.

ORGANIZATION.

Not a great deal need be said of organization in this paper, but it will be necessary to demonstrate the correct principles upon which industrial organization should be outlined, which may be done in a few words. The word "organization" is derived from the Greek word ἔργον, which means work, and is akin to another form of the same word, ὄργανον, which means "an implement or instrument" for doing work. In Latin the word is "organum," and from this the English words "organ" and "organization" are derived, the latter applying to the complex work of modern times and indicating in its most modern application the framework of personnel and their interrelations, as an instrumentality for the performance of work.

Plate 40 exhibits an up-to-date example of organization as existing in one of our great shipyards, which will serve to illustrate the principles involved under any application. It is seen that the lines of authority flow from the source, which in this case is the Board of Directors, through the president, to the various subordinate entities. I think if the efficiency engineers had chosen to develop their line-and-staff theories to fit the conditions illustrated in this diagram, instead of utilizing the theories embodying the staff to cover the personnel of efficiency engineers only, the atmosphere surrounding staff organization would have been clearer than it is.

The name "staff" could in this illustration be very fittingly applied to those entities radiating from the president excepting in the one vertical line leading through the general manager to the plant, which might be called the line. That is to say, the word "Staff" might be applied to treasurer, assistant auditor, production engineer, vice-president and the three subordinates radiating from him in the naval architect, chief engineer, and estimator; and to said staff of the president could be added the staff of the vice-president-and-general-manager in the additional offices of sales agent, purchasing agent, assistant mechanical engineer, and head in charge of training apprentices. Hereafter I will call these the staff, as relates to the organization. The line I would call that channel of control of the plant proper through the officials indicated in the vertical central line from Board of Directors to the president, vice-president-and-general-manager, to general superintendent, to the foremen.

It is to be noted that the "Superintendent in charge of all submarine work" has been omitted from the above because the line of control descending through

him is in the nature of line as regards the execution of submarine work in the plant under the foremen involved. The essence of the descent of control is not violated by having a subsidiary descent of power through line control as in this special case. In the diagram, as may be seen, the staff has not been connected with any lines of authority running direct from them to any official or foreman in the plant, the reason being that in this one particular it is the aim to describe a change which has taken place in modern management, and which ought to take place in all industries not yet so modified, by withdrawing all powers of control from officers comprising this staff over the shipyard, excepting through the proper head in the line, as indicated in the diagram. In other days there was immense confusion of effort and lack of control through the general exercise of various degrees of authority over the yard foremen and officials by the various branches of the staff.

Now the correct principle is that authority only descends through the line, and the yard officials are given to understand fully that they are not subordinate to any member of the staff, nor are they expected to carry out any instructions emanating directly from the staff, but only from their proper superior officials in the line. By these means the individuals of the line can be and are held absolutely responsible for the results, and all authority in connection therewith is delegated to them without subdivision with any chief of staff in the sense that I use the term. On the other hand, in order to supplement the breach which would otherwise exist from lack of contact between the staff and the yard officials, the staff and said yard officials have been drawn very closely together through an infinite number of points of physical contact, in a cooperative way, which is understood to be purely cooperative and in no sense due to any authority of control lodged in the staff. To secure such cooperation, rules are laid down by the heads of the line stipulating the part to be performed by the staff and by the yard in connection with the systematization in vogue, whereby they work in conjunction with each other in the performance of a continual line of action flowing from one to the other, and are supposed to consult very closely not only informally with respect to the details of any work at hand but also at the conferences in assembled committee. By this means a very even and sensitive balance is maintained between the yard foremen and the staff, through cooperation in direct contact and through the heads of the line as affects control. By this means also the operation of each head of staff is confined strictly within the territory of his own sphere and his responsibilities are bounded thereby.

In the case of the chief engineer, for example, he would not control any yard superintendent or any subordinate thereof, but in order to perfect his work and bring it up to date so as to include upon his plans every detail or information that the yard foremen will need, he must consult not only with the yard foremen but must also go into the yard and examine into the work in every way, and have full powers and authority to do so. Likewise, the foremen must get in contact with the chief engineer wherever necessary in order to secure or convey information that

will be of value in carrying out the work from his point of view. But the chief engineer should possess no authority to direct a foreman to vary so much as one iota from the plans made in the draughting office, excepting as obtained on authority of the line officer in charge, and the foremen should have no right to vary from the plan except with the authority of the line head common to both. By this means alone can responsibility be brought home to the right party, and it is in this way that the education of the foremen and the chief engineer is perfected and a balance maintained which will permit of placing responsibility for errors.

This is the correct principle upon which any industrial plant should be organized, and if anyone should wish to apply the terms "Line-and-Staff" in the sense that I have used them here, I shall be willing to concede that it has an application in industrial management. Reverting, in this connection, to the four heads of staff of Mr. Emerson, it will be remembered he had, first, a welfare man; second, an equipment man; third, a material man; and fourth, a methods and conditions man, or straight out-and-out efficiency engineer, as I would call it.

It is seen that these four heads, if utilized as separate entities in any establishment, could very well be added in the same relationship as the other heads of staff as I have called them on the chart. If that were done, and if their work were consolidated under a chief of staff, as one application of the Emerson system indicated, said chief of staff could very well be represented in the same place and relationship as the "production engineer" on the chart. In fact, the work of a production engineer is very well described in part by Mr. Emerson's four chiefs of staff, and so I hope to make it clear that the Line-and-Staff propaganda of the efficiency engineers would seem to capture the whole of the staff for themselves, in so far as any literature on that subject can be interpreted by the writer. I think, however, the above variation in the sense of the terms, if acceptable, would furnish a very handy set of terms in which to convey the idea of staff in management, but I would be wholly unwilling to recognize it as applied only to the efficiency engineers, however much I believe that an efficiency engineer is a desirable acquisition on the part of any complex industrial organization, and so I hope a place will be conceded to him among the staff, and that he will enlarge the term to cover the balance of the staff along the lines illustrated herein.

It is believed that these lines of control must of necessity be maintained in order to permit authority and responsibility to go hand in hand at an even balance, on which the efficiency of a plant depends, but it would be useless to set forth any particular subdivision of authorities or lines of control to fit any plant or any set of individuals as they are all different and there must be variations depending mostly upon the qualifications of the officials involved. Plants are reorganized frequently owing to changes in the personnel, or owing to the qualifications of individuals which are found by experience, whereby the work of one is subdivided or transferred to another, and the subordination of one is transferred variously, depending upon the circumstances at the time. This must always be done, and there can be no rule with respect to such arrangements.

In one great shipyard where a man shows an aptitude and a strong desire to engage in any particular line, they give him the chance, and if he makes good they enlarge his purview and shift duties and authorities, according to the abilities of the personnel. It is there recognized, as it must be in every correct organization, that the qualifications of the personnel are of vastly more importance than an arrangement of organization, as it is everywhere recognized that a good personnel with a poor organization is much better than the reverse, and that there are a number of lines of organization which might be made equally suitable to a given personnel.

The purpose of organization is merely to permit individuals to operate at their maximum efficiency, and consequently changes must continually be made and varied to that end and made subservient thereto. There can be additions or subtractions among the officials of the staff, some can be subordinated to others, and so likewise among the foremen and other officials of the line; but whatever is done in this connection should not violate the principles of line-and-staff arrangement as outlined above. Under this arrangement a test may be made by writing out the duties of each head of line and staff, and none of these duties should overlap or conflict. If two heads have a duty which follows the same description, there is conflict and the organization is defective. Furthermore, each head must be tested as to his qualifications to perform his assigned duties, must be left free to perform them without interference, and must then be held responsible for the results. By this means every official stands on his own merits, and you have now to add only an incentive in the form of a bonus to each official for the particular output that he can personally influence, as is the practice of Mr. Charles M. Schwab, and you will have a form of organization that cannot be improved upon. It is seen that in circumscribing the exact functions of each in this way there is reward for merit and punishment for shortcomings, responsibility fixed and merit measured.

It is to be noted in connection with this discussion that the points of articulation in the framework of organization are bent and located to the purposes thereof, and made subservient to the qualifications of individuals. Parallel to these lines there are two additional sets of framework that have been built up, one consisting of the mechanisms of systematization forming a vehicle of instruction and method governing the performance of work, and the other a framework of cost accounting, consisting of mechanisms reporting back the results of work in the shape of cost returns. It is well to keep in mind that the points of articulation of these three systems necessarily coincide, and necessarily follow the framework of the organization. These three systems radiate from the management and from the line heads thereof in control of the source, and the mechanisms of all comprise the sum total of the mechanical tentacles and feelers which the manager uses in order to find out as from a flowing record what is going forward at all times, and through which, after the acquiring of information, to make his presence felt throughout each branch of the establishment.

A works president, or other form of manager, must have under his complete

control the organization, the mechanisms comprising the paper work and other forms of systematization, and also the mechanisms of cost accounting. They are the implements through which he accomplishes results, and each one must perform its functions to the desired degree of refinement, and this illustration is for the sake of introducing the framework of cost accounting into this discussion in its proper relationship and bearing. There is no reason for a pilot to turn the wheel unless there is a telegraph system to report back the angle of the rudder; no more can an industrial manager be able to steer his ship through the channels leading to economy unless he has a cost accounting system to report back the direction in which he is going. As the compass is to the mariner, or the ticker to the stock broker, so the cost accounting system is to the works manager, and mention is made at this point in order to bring out that it necessarily runs parallel to the lines of organization, is concurrent therewith, and articulated at the same points.

COST ACCOUNTING.

With the advent of science in modern management, there has arisen a clash between the engineer and the cost accountant as to which one of them should control the cost accounting of an industrial plant. Under the simple management of other days, the cost accountant was known as the bookkeeper, whose duties were purely clerical, and whose books were not such a sensitive instrument of analysis of the current management as under present day conditions. With the increase in the complexity of the manufacturing business, the bookkeeper has expanded into the cost accountant, and, in default of an efficiency engineer, has been required to extend himself as far as possible in living up to the increasing requirements imposed upon him. By virtue of the fact that engineering questions embodied in cost accounting have been placed upon his shoulders, he has acquired perhaps more influence in modern establishments than the new arrivals, the efficiency engineers, would permit. As a matter of fact, with the analysis and standardization of management, the cost accounting records have been found to be the most potent instrument in the hands of the manager, and its new importance has been brought about by the substitution of new forms and records invented by the efficiency engineer, in lieu of the former accounts. The engineer has, therefore, very justly set up the claim that cost accounting is a function of the engineer and not of the bookkeeper, and has insisted upon the establishment of such new relationship, which has been very generally accorded him in the world of industrial management of to-day.

The cost accountant of an establishment is sometimes known as the comptroller and sometimes as the auditor, seldom as the bookkeeper. It is his proper function to supply and keep the books, forms, tables and nomenclature which comprise the vehicle of cost accounting, and to be the instrumentality through whom said vehicle and its contents are administered; his points of approach are the balance sheet and the profit and loss statement, and his work includes the keeping of the records upon every detail of cost. Upon the other hand, the contents within the vehicle of cost accounting should be controlled by the engineer since they spring

from the underlying reasons growing out of the profession of engineering, and of which the engineer is the qualified interpreter. It is for this reason that cost accounting has been recognized as the function of the engineer and not of the cost accountant.

Cost accounting, in this sense, has been thus appropriated by the engineer because of the necessity of maintaining immediate and adequate flowing records of costs which the engineer requires in order to be able to locate and abate current inefficiency. The establishment of unit costs, whether with or without premium work, has been applied to what engineers call "work equivalents" that are used as standards of comparison between one job and another that are alike. Comparison is the instrument of experience, and the engineer is necessarily the judge. These functions of cost accounting are foreign to bookkeeping *per se* and to cost accounting in the bookkeeping sense, and the point raised by the engineer is to the effect that a cost accountant who is not an engineer should not be charged with the responsibility of undertaking that portion of cost accounting which deals with questions of engineering, and are foreign to his profession. It is not necessary that the cost accountant and the engineer should be physically separated in an industrial establishment, but the cost accountant, if he is not a trained engineer in person, should be subordinated to the engineer sufficiently to permit the latter to control whatever features embodied in the accounting may be necessary to be utilized as a standard of comparison and whatever of the contents of the cost accountant's books may fall within those questions of engineering which are nowadays leading considerations entering into the cost keeping methods of an up-to-date industrial establishment.

It is the engineer who should determine the rules governing in cost accounting, and the function of the cost accountant should end with the execution of said rules. The term "engineer" applies to efficiency engineer, or to whoever among the technical officials of the establishment undertakes to represent the works manager or other line executive, whether he be naval architect, marine engineer, mechanical engineer, or other trained professional in the line of work which is made subject of the accounting.

In a certain great shipyard employing the contract or group piece-work system of payment, it was found impossible for the foremen and piece-work subcontractors to guide their work of to-day unless they received at the beginning of work hours a detailed report of the costs of yesterday, and it was necessary to remodel the cost accounting department in order to provide such immediate records before such system could be satisfactorily established and maintained.

Mr. Halbert P. Gillette stated "That bookkeeping and cost keeping must be divorced if there is to be a simple effective system of ascertaining the efficiency of workmen, and permit of such study of their performance as will result in greater efficiency."

Mr. Harrington Emerson says:—"The modern comptroller and the efficiency engineer must affiliate and jointly evolve records satisfactorily for the purposes

of both. * * * It is the business of the efficiency engineer to eliminate wastes, and it is the business of the auditor to carry the accounts in such a manner as to record the results of the efforts of the efficiency engineer."

Mr. A. Hamilton Church, in his book on "Production Factors," speaking of the determination of the factors entering into expense, stated:—"The determination must obviously be made, as in the case of those factors, not by an accountant but by an engineer." The *Iron Age,* in discussing a paper by Mr. Gantt, stated:—"The aim of the paper was to make the financier and the cost accountant subordinate in the manufacturing world to the engineer, and if the comments which the paper evoked are any criterion, the engineer is to-day preparing to take his rightful place and assume the credit for, as he now assumes the burden of, making the industries of the country successful."

There are three methods that have been used in cost accounting, the determination of direct labor and materials remaining the same in each, the point of difference being in the method of ascertaining the indirect or overhead charges. Mr. Church, in his books on "Expense Burden" and "Production Factors," has described these differences. The three methods for ascertaining overhead or indirect charges are:—(1) the percentage-on-labor method; (2) the hourly-burden plan, and (3) the machine rate.

The percentage-on-labor method is obtained thus, for a given job:—If in a certain shop the direct labor cost of all jobs during a given month is $100, and if the general expense is $50, labor and materials, the overhead to be added during the succeeding month to the direct labor of each job is 50 per cent. If a certain job cost $10 for direct labor and $5 for direct materials, the overhead burden would be $5, thus making $20 for the total cost of the job. The advantage of this method is that it is the easiest and cheapest method of averaging overhead charges due to the fact that under any system of cost accounting it is necessary to obtain the labor costs for purposes of wage payments, and it is easy to sum up the amounts already available from the pay-roll data. The disadvantages lie in the inaccuracy of the amounts allocated to each job, as compared between jobs performed in the same shop. This method assumes that the elements of indirect charges will be equal on all jobs, but in reality such is not the case. One job may require more supervision than another; another, more attendance to machines on the part of helpers, cleaners, oilers, etc.; another, more office supplies; another, more floor space, rent, heat, light, power and the fixed charges; and another, a more expensive machine, or more crane service. Indeed, another may be done by hand, where no power charge embodied in the overhead would be due at all; and maybe the cheapest labor will require the greatest proportion of the supervision.

At best, the percentage-on-labor method is a crude approximation, which is only excusable for its facility, and is permissible in establishments where there is no great variety of output in the finished product. It has been largely used in England and the United States from the beginning, especially in the shipbuilding industry, and it is only in comparatively recent years that more accurate methods

have been attempted. Obviously, in a shipyard where only a single class of ships is turned out, all labor and machinery contribute alike towards each ship, the total cost of which will be correctly determined by this method, since in a given shop the errors of excess on jobs at certain production or work-place centers will counterbalance those of deficiencies at other centers, and will balance each other in the sum total for the shop. Thus the true cost of the completed ship is ascertained, and when such ship is sold or bid on in the open market in competition with ships built at other yards there is no fictitious status tending to deceive the parties and undermine the trade.

The conditions are opposite, however, when all the work of a shop does not contribute to the same unit output. For instance, let us imagine a shop where each machine turns out a different product, say, hammers, saws, anvils, screws, buckets, etc., this example being purely hypothetical and illustrative. There are certain shops that do produce a variety of output. In such a case it becomes necessary to ascertain the true cost of each article for competitive purposes, and an averaging method of percentage on labor will not differentiate accurately between the machines and work-place centers of a shop. Here is where the method falls down, and whoever sells saws at $2.50 each, that cost $2.75 to produce, but which the percentage-on-labor method erroneously indicates to have cost $1.25 each, is inviting disaster to himself and his competitor. If the error on this item should be compensated for by an overcharge on anvils so that a $5-real-cost anvil should cost apparently $6.50, and is offered at $7, the result is just as bad for the one party or the other. It is not likely that all manufacturers will make the same mistakes in determining costs, as the complexity of different plants varies. If, in a given shop, a group of machines contribute to a certain finished product, it would be necessary to ascertain accurately the cost of the group, as differentiated from other groups, in order to fix the right price. In a jobbing shop, where any combination of machines is liable to be used on the different jobs within the range of the shop, obviously the machine-rate method only would be sufficiently accurate for use. Percentage-on-labor would not be permissible.

The "hourly-burden" method consisted of distributing the overhead shop charges upon jobs by spreading them equally over the machines on which the jobs were done at an equivalent hourly rate for each machine, that is, upon a machine-hour basis. Supposing in a given shop the overhead monthly charges were $100, and the time made by two machines therein was 200 hours each, or 400 hours altogether. Averaging the results would allow $0.25 per hour on all jobs on either machine. The defect of this method is obvious, since one machine might be a large, highly expensive machine and the other might be a small, insignificant machine. These extremes are cited in order to accentuate the defects in any shop where the machines are different in size and value of output, aside from the proportionate cost of the labor attendant upon each. With this method the machines as well as the men must be timed in the time-card returns and accounts, and it is doubted if it has ever been justified in any shop in view of the extra expense.

The machine-rate plan has been devised in order to differentiate the charges at the point of the tool. Each machine, bench, or other work-place unit is called a production center, and each production center is made to bear its own separate direct charges and in addition thereto all overhead charges which can be allocated thereto by proportional rate or by averages. It is the rule to differentiate along natural lines to the fullest extent and to average what cannot thus be differentiated within reasonable accounting limits. At any particular machine the direct charges may comprise interest, depreciation, repairs, maintenance, oil, waste, sundries, and tool, jig and template charges, limited to the machine only. It is the American practice nowadays to include all such charges, whereas in the early days when the machine-rate was first installed, some fifty odd years ago, and until recently, it was frequently the practice to include only the machine depreciation, or depreciation and interest, in the machine rate. In addition to the above in any particular shop, there are certain other general charges running which cannot be charged directly to machines or work-place units, but must be averaged. These are heating, lighting, ventilation, power, transportation, maintenance, supervision, and rent, where rent is paid as such.

Frequently the term "rent" is used to denote the "fixed charges" which are composed of the interest, depreciation, insurance and taxes upon the land and building. It is to be noted that the interest and depreciation included in the machine rate apply only to the valuation of the machine or production center itself, and is to be differentiated from the similar items comprised in rent. Sometimes insurance may be included in the machine rate if it can be allocated at that point of incidence. Mr. Church has developed what he calls a "supplementary rate," to be used in connection with a shop running upon the machine-rate basis, and into which are charged the time or value of machines, spoiled work, removals and rearrangements of plant, fixtures, etc., loss caused by stoppage of power plant, and extra payment for overtime. These are carried in the accounts as separate items, each in its own column, so as to form an index to the current economics of the shop. The supplementary rate was applied primarily to the idle machines, in order to form a flowing record of the shop economics as between a full-going establishment at maximum output and a low rate of production at slack periods. The idle machine rates are an index to the output of the shop and furnish valuable information to the management. These charges, together with the others contained in the supplementary rate, are distributed over the running machine rates of the shop, Mr. Church states, preferably on the basis of averaging by the hourly-burden plan. I think the proper way to distribute is upon the proportional value of the machine rates, by allotting a proper percentage to each, which is consonant with the idea of differentiating charges on the machine-rate basis in the first instance.

In a great shipyard having say twenty or more shops or separate departments, there is also the administration building, which forms a third point of incidence for all those general charges which cannot be allocated at the point of the shop or at the point of the machine. These general administration charges must

be distributed along the lines of natural complexity as far as an analysis will permit, by pro-rating proportional charges to any shops on all items, and these distributed over the output of the entire plant taken as a whole. Thus the three points of incidence are, first, the production center; second, the shop, comprising all general expenses which can be allocated to the shop and not to the production center; and third, the general overhead applying at the point of the administration building which cannot be narrowed down to the point of the shop or to the point of the machine.

Mr. Emerson has developed a cost formula as follows:—

Direct material $= QP =$ Quantity $\times$ Price.
Direct labor $= TW =$ Time $\times$ Wage.
Direct charges $= tR =$ Time $\times$ Machine-rate.
Burden-on-materials $= QB_p =$ Quantity $\times$ the material burden units.
Burden-on-labor $= TB_w =$ Time $\times$ Burden-on-wage units.
Burden-on-direct charges $= tB_r =$ Time $\times$ Burden-on-machine-rate units.

From the above, the cost formula becomes:—

$$\text{Cost} = Q(P + B_p) + T(W + B_w) + t(R + B_r).$$

This formula may be developed in tabular form to cover the natural lines of complexity in any particular establishment, and it will be found desirable to apply Mr. Church's supplementary rate where applicable, and each plant will deserve a modification as to the details generally in the direction of eliminating unnecessary complexities which this formula might otherwise lead into. It must be remembered that it is not necessary to attain minute accuracy in distributing overhead charges and all methods should be lumped and shortened where the purposes in hand will permit, so as to avoid complexity in the bookkeeping. In determining power for the machine-rate, the machine may be motored, or the shop may have a total switchboard consumption, and where this exists it is desirable to determine the exact power used in horse-power hours. All shops and machines so arranged can be determined accurately, and the balance pro-rated by estimate Sometimes power can only be measured at the central power plant, and the balance estimated for each shop served, as well as for the machines and work-place centers. The fixed charges, or rent, can be distributed in any given shop proportionately to the square feet of floor occupied by each production center. Supervision and maintenance are chargeable directly to each center, and what cannot be so charged can be averaged or proportioned with the use of due discretion, based upon the machine rate, or upon the labor maintained or supervised as the case may be. In power, supervision, and maintenance, Mr. Emerson distinguishes between men and machines, and differentiates between the two with the overhead. I think this refinement un-

necessary, as the straight machine rates and direct labor with the usual overhead and supplementary rate ought to be entirely sufficient for any shop, and will be found deserving of simplification, without introducing further subdivision and complication in the accounting.

It may be mentioned here that the term "common sense" has been over used by production engineers in connection with all phases of production and accounting, and there is no branch in which its use is more efficacious than in determining the desirable limits to which to extend the principles of cost accounting for any particular shop. The reason why cost accounting is a function of the engineer is because he is supposed to understand the bearing, reasons, and purposes in view, and to so bend and modify his accounting system as to secure the essential charges in their proper points of allocation without introducing unnecessary refinement. This is a matter of judgment developed with knowledge and experience which cannot be conveyed in a treatise upon the subject. It may be added as a corollary to this end of the question that the province of the bookkeeper is all the more definitely fixed by these considerations and is confined not to a determination of what the cost accounting system shall consist of, or how it shall be modified to suit the end in view, but after these have been determined by the engineer it is the province of the bookkeeper to go through the automatic process of following the forms as a matter of routine which have previously been laid down by the engineer.

Out of the above considerations, tables may be built, in the form of "control accounts," which serve the following purposes:—

1. To show, in the accounting sense, where the money went and how it was expended.

2. To show the cost of "work equivalents" for comparison, at different times and places, of the same or equivalent jobs.

3. To indicate the running cost of work, as a means of locating discrepancies and rectifying same while in process.

4. To compare the final costs with the estimates, to locate waste or rectify future estimates.

5. To differentiate expense distributed at the production center from that distributed as a shop overhead, and their relationship.

6. To indicate the supplementary rate, and, through it, the economics of the shop in relation to idle time and other odd expense.

7. To indicate the cost of each process, in each part, for fixing bonus and premium rates, or for determining efficiency of production in the technical sense.

8. To indicate cost, profit, and selling price, in the commercial sense, as a means of selection or elimination of products that can or cannot be profitably manufactured.

As few or as many of the above considerations may be brought out and developed in the cost accounts as the nature of the business requires.

Under naval accounting practice the above itemization is reduced to three

heads, two of which are called "fidelity accounts," one relating to property, the other relating to money, and the third relating to cost accounting by units of output, covering purposes and objects. This third branch is the cost accounting in the main, which purports to serve such of the purposes outlined in items 1 to 8, above, as it has been made to cover. I shall not attempt, in this connection, to say whether it is adequate to the purposes of the engineer, or to indicate whether it contains defects, to account for the discrepancy between navy-yard and ship-yard costs. The writer has a definite opinion on that score; but this is not the time nor the place to discuss it. In naval practice, the leading branch of accountability is that of appropriation accounting, following legislative authorizations, and that branch has penalties and responsibilities attached to it which assure its predominating influence. Cost accounting, as a controlling incident of industrial administration, is only a development, as far as it goes, which is voluntary and within the tastes and influences of the various parties in control, from time to time.

In a shipyard, as we have seen, where only one class of ship is built, say merchant freighters, of a given approximate tonnage, such as existed in England in times past, it is obvious that the same machines are used on every ship of the kind; and the reasons for differentiation in output disappear to all intents and purposes, as it would not be justifiable to expend the necessary amount upon cost accounting by the machine-rate method for the sake of a differentiation in product which does not exist. If, however, a shipyard produces a variety of vessels, such as merchant ships, battleships, destroyers and submarines, the reasons for differentiating appear, and it would be exceedingly advisable to examine into the question of machine rates with a view to differentiating between output as far as the circumstances should warrant.

I am qualifying the above for the reason that no arbitrary rules should be laid down especially on this subject, as each situation should be examined along the lines of natural complexity to see what differentiation is desirable and practicable before the undertaking. In a navy yard devoted to repairs to naval vessels only, there is no reason for the existence of the machine rate, since the output cannot be compared with any figures obtaining anywhere else. It would only be necessary to establish the machine rate in case private shipyards were allowed to bid against the navy yards upon naval repairs; if such were done the process and costs could then be compared more accurately on the basis of the machine rates. Such a contingency is not conceived, but is merely mentioned for the sake of illustrating the principle involved. In a navy yard, however, where naval vessels are under construction in addition to the ordinary naval repairs, it would be necessary to establish the machine rate in order to be able properly to distinguish the building from the repair work, so as to obtain an accurate cost for comparison with similar vessels built in private shipyards.

This illustration carries the cost accounting to a fine point, and such measure would seem justifiable only in case the machine rate were subject to be utilized

under a bonus system, as the ordinary averaging methods will otherwise suffice. That is to say, in a shop, such as navy yard shops, where the bonus cannot be applied, there appears insufficient justification otherwise, merely for the sake of carrying the accuracy of details down to the fine point, to attempt the machine rate, involving, as it does, a new system of time accounting so as to time the machines as well as the men upon different jobs, and in addition the idle machines. The additional administration, personnel, and paper work necessary to keep the time of running and idle machinery, and other production centers, is too great to be justifiable by any comparative purposes in hand in connection with the output of such establishments. Only in factory costs, with variable output, would it seem desirable to establish the machine rate, for its own sake, in the absence of a bonus.

Comparing shipyards and navy yards, the one with and the other without bonus work, the costs are bound to favor the former in sufficient measure to be able to discern without parallel cost-accounting methods. To make a real comparison, as well as to establish an acceptable navy yard system, bonus work should be done on parallel lines with the shipyards, and both should apply the machine rate on account of the variety of output of each in this country. Then a comparison of costs would be valid, and a modern cost-accounting system applied to navy yards would be worth while.

WELFARE WORK.

Reverting to the point of the tool, the preponderating importance of *the man* has been shown, the human element over-topping all other considerations in intensive production. The physical welfare, health, and mental attitude of the workman must be perfected by a multitude of services as numerous as the human wants are complex. To-day it is held essential by the new type of manager that all kinds of modern facilities, comforts, and even what were formerly considered luxuries, are necessary for the workman personnel in order to reap the maximum benefits of production. This belief has grown with the increase in the wealth of the country and might be, in a larger sense, regarded as a proper and somewhat inevitable means of division of the spoils. As the heads of corporations have grown richer and have acquired habits and facilities contributory to their happiness, so the workmen, by a slower but nevertheless definite process, have shared in the general uplift, thanks to the processes of democracy, operating through organized labor and through governmental easements. This general uplift is accompanied by arguments in justification on grounds of efficiency, and so it is held by the representatives of labor, and by managers in reflex action, that these ameliorating innovations in management are altogether necessary for maximum output. Certain it is that a vast difference exists between the condition of the workman now and twenty-five years ago when the hours, pay, and factory and home conditions were infinitely inferior, as well as intolerable from the present-day viewpoint.

These reforms, which nowadays in large corporations have reached vast proportions and are extended in multifarious directions, have begun in the larger

establishments, and have enveloped the smaller plants, in those particular betterments which have directly affected the workmen within the shops while engaged in their daily tasks. First, toilets were installed. A certain large establishment has been cited as possessing a few years ago not a single toilet within its own properties, but the workmen were forced to have recourse to the saloons in the neighborhood for that facility. With the lapse of time and the size and wealth of the corporations, the toilets have grown to be adequate, properly placed, and sanitary. The scientific analysis of the auxiliary services necessary to keep the tools of a machine in perfect condition and continuously on the job has been applied to the man, and the wastage of time on the part of the men in routing themselves to and from the toilets is quite as important, and indeed more so, than as affects the machine or the tool. The health of the man is more important than either, and without both the zest and enthusiasm necessary for maximum production in perfect health would not be possible. Next, lunchrooms have been established where the men have been afforded those personal considerations in keeping with their dignity as men, in contrast with the former custom of eating a cold snack at whatever place around the shop they could find.

As the machine needs the proper oils, so the human body needs more care in its lubrication than a minimum supply through a cold snack will render, as a formal lunch at table necessarily carries in its train those additional auxiliary supplies that the makers of cold lunches do not find it convenient to pack. Furthermore, man is a gregarious animal, and that the state of his mind should survive at maximum potentiality he must meet and converse with his fellow-men, and the practice of introducing restaurants in factories has contributed also in like measure to aid the processes of digestion, not possible where the cold meal is gulped down quickly, in silence. Furthermore, the enthusiasm of the workman-personnel as a whole is greatly enhanced through the contagious effect of social contact among the individual members, and the social instincts are developed not only in the restaurant but also in various other phases of collective social institutions which bring the workman-personnel into contact with the individuals of the superintendent and managerial forces forming the official personnel of the establishment. Consequently, the most up-to-date plants in commercial industry, including private shipyards, have introduced the restaurant as a means of bringing about social contact of this kind between officials and workmen to an extent never dreamed of heretofore.

Where the managers and superintendents of a company are thus brought into daily contact at the table, in committee, and in the shop, with the foremen and the workmen on the one hand, and with the inspectors representing their clientele on the other, there is the best hope of mutual understanding and of the maximum of cooperation of all hands in the direction of increasing the output. Under such an arrangement there is the minimum of friction and misunderstanding, and the maximum of good will, all of which contribute to a combined effort of all individuals leading in the direction of creative and not destructive work. It can

easily be seen as a result of experience on the part of those plants that have tried it, that the stream of action is increased in volume and force wherein all molecules are headed in the same direction of interest involved in the increased output. In the words of Ida M. Tarbell, "You can't fuss with the fellow you eat with."

Next, there have been introduced washrooms, coatrooms and showers in sufficient numbers and locations to serve the workman-personnel and permit them to obtain the facilities necessary for rapid and efficient transition at the beginning and end of working hours, as well as to supply those comforts necessary to make them the most effective human force available for the plant. These facilities have been introduced in proportion to the size and wealth of the factory or corporation. Equal in importance has been the establishment of rest rooms and ladies' retiring rooms, which have been found particularly applicable in the case of factories where there are women employees, as it is frequently necessary when members of the working force are not feeling well to occupy these rooms in order to restore that degree of health which is necessary for efficient work, as well as to provide a place where those who are ill can be properly cared for until removed to their homes or to a hospital. Scientific investigation has been made of such services as developed from the needs in factories, and it has been found of vast importance as affecting the health and efficiency of the working body as a whole, as well as in reducing the labor turnover and of providing those necessary comforts which the humane treatment of modern industry has recognized as being in the best interests of the working personnel of the community and of human society, as well as directly and indirectly the well-being and profits of the manufacturing concern.

The efficiency engineer and welfare manager have been directed of late years to the sufficient lighting of shops and buildings, which is a science all by itself. Scientific analysis has shown that eye strain, headache, moodiness, lack of interest, and other physical drawbacks are induced by the effort to do tasks in dim light. Certain factories that have been placed under such an analysis have shown accidents to be more frequent in the dark hours of the day and in the dark seasons of the year, and in those buildings that have been improperly lighted. In other cases the foundations and flooring of buildings have affected the workman-personnel, as standing or walking upon a cement or steel or stone floor is more tiresome than upon a wood floor, and the problem of ventilation and of temperatures has an equal bearing upon the comfort and, hence, efficiency of the workman. The temperatures adopted by the Brown & Sharpe Manufacturing Company are as follows:—Offices, 67 to 69 degrees; storerooms, where workmen are not regularly employed, 40 to 50 degrees; shop floors with workmen seated, 67 to 69 degrees; shop floors where workmen move about, 65 to 67 degrees; foundry, smith shop, and carpenter shop, 55 to 65 degrees.

It goes without saying that drinking fountains are essential at suitable points of travel among the working force to avoid those evils which existed in the case of a plant a few years ago whose workmen were obliged to go to the nearby saloon for their drinking water.

For the sake of efficiency a short man is not permitted to work with a pick or other tool suitable only for a tall man, and a short girl who would be comfortable on a small chair is not permitted to be supplied with a tall chair. Where the health and comfort are affected by occupational conditions, the shoes, coat or other garment of the workman have been made special to order in certain factories, to suit the work in hand. Girls have been clad in neat work trousers, or overalls, where their dresses would be an element of danger or inefficiency. The tools, chairs, benches and machines have been arranged, raised or lowered or otherwise accommodated, to eliminate fatigue from the operatives. It has been found that health and productivity thrive together in direct proportion, and the highest efficiency brings the least discomfort and fatigue to the workman.

In the workshops the men are affected by occupational diseases, to prevent and eradicate which education through organized effort is the most important factor. Where lead or lead paints are worked in fusion or in close spaces and lead poisoning is liable to affect the trades of the painter, the potter and the melting man, rules for prevention and cure should be published and placed in the hands of all interested workmen, or posted so that they cannot avoid the information. Textile workers must be prevented against tuberculosis, washer women against eczema; match makers against "flossy jaw"; stone masons and sugar refiners and candy makers against skin diseases peculiar to their trades; butchers and handlers of animal products, tanners and furriers, against anthrax; gardeners against the irritant plants they handle; workmen in general against tremors, spasms, palsies and neurotics, and other ills due to lint, dust and gases or other product of varying factory conditions. Scientific analysis is necessary in each case, with the application of the remedy through educational propaganda.

It is well to remember that the best general rule to follow is to provide good air, proper sanitation, regular temperature, as well as education upon precautions. The physical examination has been introduced in a great number of modern establishments in connection with hiring and firing, and some establishments have held an annual physical examination of the workmen which is regarded as of the highest importance not only as relates to conditions at first employment but particularly as affects the trade diseases and the elimination thereof, and such an examination would be justified in establishments sufficiently large to afford the facility, upon the last mentioned consideration alone, aside from the follow-up purposes of keeping a running account of physical defects determined on hiring.

Within the shops, as well as without, the introduction of system, order and cleanliness has superseded the more obsolete conditions of disorder and dirt; and in addition to architectural beauty embodied within the buildings and other facilities, factories and plants have been of late years supplied with beautiful surroundings, grass, flowers, vines, shrubs, roads and walks, all contributing to enforce the spirit of order and of contentment, of happiness and of efficiency, in an atmosphere which gives breath spontaneously to good will and enthusiasm on the part of the worker for the interests of the employers, which under such conditions they identify with their own. One of the great private shipyards has in recent years been

changed as if by magic from the traditional shipyard of the past into a picture place. embodying the most advanced practice in its landscape appearance.

A few years ago, when the first step was taken in the transition from the traditional disorder maintained by shipyards of the past towards the new shipyard of the future, notice was served upon the workman in a very practical and never-to-be-forgotten way. Around the foot of a large tree near the entrance to the shipyard suddenly there appeared a ring of geraniums in full bloom which had been transported and planted over-night. A crowd of workmen were noticed, upon the afternoon of the first quitting time, to have approached the tree on their way homeward and, eyeing the flowers, they gathered together as if by intuition, and spontaneously, without preconcerted action or individual direction, but of their own inner feelings, took off their hats, waved them in the air, and cheered in unison. It is believed a no more practical example could be cited to illustrate the inevitable effect of beautiful surroundings upon the sentiments of the workmen, and it may be asserted at this point that sentiment has come to be regarded as a real asset in business, and should be cultivated as a legitimate part of the necessary costs in the conduct of a manufacturing establishment.

Mr. A. P. Loring, president of the Plymouth Cordage Company, of Plymouth, Mass., in an address before the Constitutional Convention in Boston, August, 1917, described the labor conditions existing at the plant of said company, which is one of the largest and most successful individual plants in New England. One thing was particularly striking, in respect to cleanliness, which related to the committee who selected and designated weekly the most untidy spot in the plant. To a delegation of visiting gentlemen this place, which was quite clean, was pointed out and was designated by a large signboard erected at the spot, which read as follows:—"This is the dirtiest place in this plant." The committee had to decide each week where this signboard was to be placed, and it went up inevitably in some place or other, and the result was, as might be expected, that the plant was one of the cleanest plants in the country.

The above-mentioned facilities and comforts which have been embodied in the design of modern establishments have aimed to supply the men with those facilities which, in other times, they were forced to go without or seek at the neighboring saloon, and the effect has been to reduce alcoholism, which of itself has furnished a point of temptation interfering more than anything else with the efficiency of an establishment, and with the happiness of the men and of the community. It is not long ago that the hours of work terminated so late that the men could find no bank or store open to cash their checks and perforce took refuge for that purpose to the saloon with the inevitable result. The substitution of welfare work has tended to supply the facilities and remove the temptations. "Sober First" is as important a shibboleth in management as "Safety First." The shortening of hours has also ameliorated conditions and supplied time for outside facilities, aside from the general recognition among employers that the shortening of the day from ten to eight hours has resulted in as much work and better efficiency on the whole.

The factory athletic field and social club have been inaugurated in recent years

in order to further remove the temptations, but also to cultivate the social spirit among the workmen and train them in collective action. Fresh air and exuberant spirits travel together in rivalry between teams upon the athletic field. There is opportunity for cooperative work by the employees in getting up committees and running club affairs out of which grow the opportunities of individuals to blossom into leaders in sports or in getting up things.

Herein lies the opportunity for the management to locate leaders and foremen among the men who display cooperative ability in a connection where natural leadership asserts itself in a way that cannot be mistaken. There is the home band, conducted by the employees, who furnish their own music upon occasions. At the noon hour, after the work hours are over, evenings and holidays, the employees engage in baseball, cricket, bowling, rifle practice, pool and other games and social amusements and entertainments at the club and upon the athletic field, and return to their work full of talk of matches lost and won, full of zeal, of conversation, and of song, and mindful of picnics, excursions, adventures and other diversions which are an index to the value and delight of play, all incurred through the exercise of social opportunity. Whenever the employee returns to his work at the factory with his feelings, sentiments and enthusiasm high-flown in the above vein, in the words of Tarbell, the true index of his efficiency is all summed up in the exclamation, "Gee, but this is a fine place to work!"

The best example which the writer is able to cite is the club and athletic field of the United Shoe Machinery Company at Beverly, Mass., where 5,000 employees are engaged in making the most intricate and high-class machinery to be found anywhere. The writer has visited this club and played golf upon the links with certain of the leading officials, and is advised as to the nature and results of this club. The $35,000 club-house given the employees by the company is a very comfortable and, in fact, beautiful building, as club houses go, and is located upon a plot of about three hundred acres of land, near the factory, and besides the golf links there are athletic fields for every conceivable land sport, and upon the neighboring ponds water sports are also indulged in to the fullest extent. The membership fee is only nominal, and all inhabitants of the town possess the same opportunities of membership as the employees of the company. This enhances the social spirit not only of the factory but also of the community, which is regarded as an asset worth while.

Once I asked an official of a certain company whether or not such a club at his factory operated to reduce the probabilities of such violent disagreement as a strike. He informed me that he did not believe it did, but had found that money spent upon welfare work had no return in such a connection. I asked him wherein such athletic sports tended to hold employees who would otherwise become floaters, which is aside from the value of play in the other connections above cited. He told me that at times apparently the men were not influenced in a way that could be discerned, in severing their connections with the company, but that the statistics showed that men who had severed their connections with the company and gone to

other places and found there no such social opportunities, eventually returned to the place with the club and athletic field. He found a sufficient number of instances to believe that such club and athletic field acted in this connection in the sense of a lodestone to attract men in a very definite way to return, and no doubt to hold men under current employ. I cite the above views because they came from an authoritative source and represent the embodiment of the best experience in such matters. The great shipyards of to-day are emulating the practice of social club and athletic field in some degree or other, or will be as time progresses.

The following is a quotation from the *Boston Herald* of September 4, 1917:—

"The United Shoe Machinery Athletic Association, agricultural division, held its fifth annual field day yesterday on the association's playing field at West Park, Beverly. More than 10,000 persons attended.

"There were exhibitions of flowers and vegetables, poultry and dogs. There was also a baby show. The midway attractions were well up to the standard established in former years. The United Shoe Machinery band gave a concert all the afternoon, and a 'rube' band paraded up and down the barbers' row. The clubhouse of the association was open to guests. There was dancing on the green, and a display of fireworks closed the day.

"Among those present were Mayor James McPherson of Beverly, Mayor H. P. Benson of Salem, former Representative John H. Saltonstall of Beverly, George W. Brown and M. B. Kaven, vice-presidents of the United Shoe Machinery Company, and representatives of the company from Brockton, Lynn, Haverhill and other towns.

"The winners in the fancy work contests included Mrs. W. J. Croft, Mrs. Caleb Cole, Miss Edith S. Wylie, Mrs. F. O. Sanders, Miss Esther G. Elliott, Mrs. G. F. Curwen, Mrs. W. J. Hosmer, Mrs. Richard Dowset, Mrs. Paul Thorault and Miss Ruth Cannon.

"The baby show attracted many visitors. Floretta Carman, aged 15 months, won first prize for the best developed baby; Mary Benoit of Lynn was second and Irene Kulligman of Salem third. This was a contest for boys and girls, but not a boy won a prize.

"John L. Ward, son of Ralph Ward of Beverly, was the plumpest baby in the show. Mildred Guy of Beverly was the prettiest Negro baby.

"There was a good program of field sports. Richard Klatt won the 100-yard dash in 10 4/5 seconds. Robert Bradley won the 220-yard dash in 24 4/5 seconds, and Thomas Campbell the 440-yard dash in 58 4/5 seconds. Miss Jessie Low won the 50-yard dash for girls.

"The United Shoe baseball team beat the Maples of Salem, 4 to 2.

"The committee in charge included H. M. Loomer, president of the athletic association; W. H. Titus, president of the agricultural division; Edward McGill, secretary, and Chester E. Rogers, treasurer of the agricultural division; N. B. Ellis, P. Russell Bosworth, Arthur J. Boswell, Fred N. Thompson, F. R. Ehlig, W. J. Carleton, F. A. Cook, Mrs. E. A. Metcalfe, and Miss Eleanor Paddock."

Another administrative measure necessary to be supplied to maintain the men continually in maximum efficiency at the point of the tool, so to speak, lies in "Safety First." The safety movement, the value of which was realized only a comparatively short time ago, has resulted in the present day "Gospel of Safety." If the men are injured there is interruption of the work, loss of time in every connection touching their exit and re-entry, and damage claims to be settled, to say nothing of the resulting unhappiness to the family. In a large factory, under the old conditions, with the numbers of accidents running high, the inefficiency has been found too great in every direction to be tolerated. As a result of scientific analysis, the saving upon a pure business basis has been so very great that the matter should not be neglected on business grounds only, aside from questions of sentiment, humane treatment, and enthusiasm necessary to be encouraged.

Present-day management has substituted measures for the prevention of accidents in lieu of rules for first aid to the injured. First, a scientific analysis of causes of accidents and their prevention has been undertaken. Machines have been supplied with protective devices. In one large establishment there is a safety employee in the draughting room, whose business it is to criticise every machine and installation with a view to supplying all necessary protective arrangements. By custom, no patents have been obtained on life-saving apparatus, and the inventor has worked so that all the world may enjoy all improvements that tend to save the life of men in factory work. It has been found by analysis that only a small percentage of accidents have occurred due to defects of machinery, but have been mostly due to carelessness on the part of the personnel.

The investigation of one hundred thousand accidents on the part of one large corporation resulted in showing that 45 per cent occurred in hand labor where no safety device was possible. A large percentage was due to improper clothing, long sleeves, large or loose neckties, and loose hair. This is remedied by prescribing the proper kind of clothes to wear. It has been found in one State of the Union that one-third of the accidents were due to lack of safeguards, and two-thirds to lack of inspection, organization and education in the care of the men. Accidents have always been a very great expense to business. In the three years, 1911, 1912 and 1913, the casualty expense of the United States Steel Corporation was about $7,750,000. Through safety measures that corporation spends $750,000 annually to prevent accidents, which statistics show has resulted in a total net saving in three years of over $2,500,000. In foundries, it has been found that seven-tenths of the accidents were due to burns upon the feet and legs which could have been prevented by wearing Congress gaiters and jean trousers. Every accident and near-accident should be analyzed and the causes removed for future reference. It is well to circulate among the men pictures of broken goggles to illustrate what might have happened to a pair of eyes. Photographs of injured workmen, whom the other workmen know, may be posted, and other literature posted upon handy billboards, bringing home to the workmen an object lesson sufficiently to impress them. Safety depends mostly upon training the human animal. The

Steel Corporation maintains at great expense a Museum of Safety in New York, and is running hospitals and a museum and publishing books and pamphlets on safety and sanitation, and it pays. Furthermore, the workmen grow to feel they are protected automatically by the company as a parent, which fact wins their confidence and gives them a feeling of security, which, together with other welfare measures, tends to bind them as with hooks of steel to the company.

A careful analysis of industrial accidents may be made, and forms prepared covering reports of all instances so subdivided as to indicate the cause, nature, time, place and circumstances, and the measures to be taken for prevention. Assistant Naval Constructor Weyerbacher, U. S. Navy, has developed such an analysis and carried it to a high degree of perfection. The part of the body may be named showing whether head, body, one eye or two eyes, right arm or right leg, left arm or left leg; also, subdivided by trades, such as shipfitters, shipwrights, joiners, painters, riggers, etc., the number of accidents may be scaled in percentages on the total number of men upon a chart extended as a curve over the different months of the year as a base, the ordinates representing the percentages. An analysis by trades would indicate the hazard in respect to the rates of pay in case greater pay were allowed on that account, as is sometimes the case. It has been found that the number of accidents is small upon the dangerous machines, as the employees are found to be more careful there than elsewhere.

An additional analysis may be made by a curve of accidents based on the months of the year, which in a certain great shipbuilding and repairing plant was found to occur during March and August. An analysis showed that the greatest number of accidents happened to the upper and lower extremities, and were due mainly to falls and falling bodies. The chart indicating the responsibility for the accidents indicated that most lay with the injured employee. This indicates that educational campaigns should immediately precede those two months so as to bring a realization to the workmen at that time. Upon a separate chart an analysis showed that the greatest number of accidents to the upper extremities occurred to the left hand. The antidote of this is a poster furnishing an object lesson as to the necessity of protecting the less dexterous member. A separate chart may show the relation of fatigue to accidents by plotting the hours of employment against the number of accidents per 1,000 employees. Such an analysis showed that, both morning and afternoon, the greatest number of accidents occur about the third hour of work. The remedy suggests a rest period in the forenoon and afternoon sufficient to eliminate the difficulty. A chart embodying the cause of injury may contain a curve, the ordinates representing percentages of employees, and the base may indicate the cause, such as falls, falling bodies, machine tools, flying chips, hand tools, electric current, etc. A separate curve may show, by percentage of employees, the injuries to the upper extremities, such as right hand, left hand, the different fingers separately, and the different portions of the arm named separately. A curve covering the lower extremities may indicate separately each leg, foot and toes.

In a certain ship establishment an analysis showed that accidents causing slight disability, for less than a day, were about one-half the total number. A certain analysis showed that a ship plant was responsible for 10 per cent of the accidents, that fellow-workmen were responsible for 13 per cent, and that the employee was responsible for 77 per cent, which agrees in general terms with the finding above mentioned in the case of industries in general, that the employees themselves are responsible for about two-thirds of the accidents, and the management one-third. In shipyards a separate chart showing an analysis of injuries to the eyes is very desirable where so many air tools are used, and such an analysis should show the relationship between the number of accidents and the months of the year, based upon a percentage of employees. In one yard it was found that the greatest number of eye accidents occurred in June, and another case in May. From the surrounding circumstances it was inferred that the cause was due to the workmen removing their goggles on account of the discomfort of hot weather, and consequently the educational campaign at the beginning of these months was actually found to have prevented all accidents of this character.

To sum up, the problem lies first in a scientific analysis by which the causes are determined; second, an analysis of the physical plant by which all safety devices are applied to the machinery, equipment, buildings and plant; third, an educational campaign through posters and billboards and photographs, bringing home to the workmen object lessons to arouse their interest and cooperation; fourth, a doctor and hospitals to take care of those cases which will inevitably happen; and fifth, a lawyer to handle claims that will inevitably arise. All of these means may be used, or as many of them as the size and wealth of the plant will permit.

In the spring of 1917 there was a meeting in Boston of the New England Branch of the National Safety Council under the auspices of the Associated Industries of Massachusetts. Nearly 200 representatives of accident prevention in various New England plants met, and Mr. C. W. Price summed up by stating as follows:—

"Since 1912 the Pittsburgh National Tool Company, by prevention work, has reduced the number of men killed in its employment about 90 per cent, and the number of hours lost per man through accidents, 84½ per cent. In the ten years from 1906 to 1916, the United Steel Corporation, with 250,000 men at work, saved 16,924 of them from being killed or from being so seriously injured as to lose 35 days of their time. The corporation has invested about $5,500,000 in its safety movement, and it has netted in the years from 1911 to 1915, a saving of nearly $1,000,000 a year. In 1911 the International Harvester Company, after adopting the United Steel Corporation's methods, lowered its deaths by accidents from 55 to 4. During the past five years the company has reduced the deaths 60 per cent and the number of hours lost per man through injury 61 6/10 per cent. It has also reduced the cost of compensation in all its 23 plants from 54 cents to 25 cents on the $100."

It was shown further,

"First, that not more than one-third of all the work accomplished by the hundreds of companies which have taken up the accident prevention work was accomplished by any mechanical guard that could be bought; second, that the other two-thirds was accomplished by educational methods, by reaching the workmen and getting their interest; third, that at least 65 per cent, possibly 75 per cent, of all industrial accidents, deaths and serious injuries can be prevented. And all this improvement has come through a great big pull-together safety movement."

Again, in the points of entry and exit to and from the establishment, there is another opportunity to perform practical welfare work of a high order, in "Hiring and Firing." The highest humanity is the soundest business. In hiring, it is the duty of the industrial manager to take any class of human material and discover what it can do best. There have been measures advocated to determine by phrenology, craniology, and psychology the various capabilities of human beings, but the best information indicates that nothing tangible has been derived from these sources to date, as the human versatility possesses more capabilities than phrenology would indicate, under the proper training. It is reported that Dean Snyder, of the University of Cincinnati, has investigated the claims along the above lines, and has pronounced that nothing real has been accomplished in those directions. Future investigation may reveal something more definite in this line, and this is mentioned as there are claims of various writers far beyond what has been positively acknowledged.

In every factory, which is a separate problem, the modern employer generally finds that the betterment work is not kindly received, but is viewed with suspicion as a rule, and it is only where the welfare mechanisms have been extended that the management are permitted to gather the conclusion that all is well, and the evidences are most frequently supplied unconsciously by the employees through the degree of response visibly rendered as well as through the statistics and other available returns. Side exhibits of real gratitude are not a part of the system and are not to be expected. The dividends, however, are none the less real. In hiring, the health of employees and of the collective neighborhood forming the reservoir from which they are, and are to be, drawn is greatly enhanced by the physical entrance examination, as well as by the annual physical examination which has been and which should be practiced. In one State of the Union, the statistics show that there were only four establishments that conducted annual examinations before 1914. In 1915 there were 42, and over 23,000 applicants, over 1,000 were physically rejected on account of vision, hernia, and heart diseases, in this order. Tuberculosis and the social diseases figured only in a small way.

It is not tuberculosis, or the fevers, or the trade diseases, or troubles requiring operations that are the most serious, but the apparently minor degenerative diseases, which the individual does not realize without a medical examination, that react so heavily upon industrial life, such as thin blood, nervous ills, poor kidneys,

bad digestion, and run-down condition in general. The medical examination is of great value as follows:—First, to employ the man in the work for which he is physically best qualified; second, so that unjust claims for injuries may be avoided; third, to protect the employees of the plant by preventing the introduction of communicable diseases, by determining in the annual examination physical defects in their incipiency, and by educating and advising industrial workers how to care for their physical well-being, even though they should be rejected as a result of the examination. The returns are to be had in the advent of workmen so advised after their diseases and defects have disappeared.

In the hiring of men, one of the great shipyards found it desirable to establish an elaborate employment bureau, in a new and ample building, operated under the welfare manager, which embodied the best ideas of a great number of plants visited throughout the country by a committee of company officials. The ideas embodied represent the best practice found in American industry and take into account the influence of hiring and firing upon the labor turn-over and the unemployment problem in general. These principles involve, in hiring, the supplying of accommodations for the men who are applicants for jobs so that they may be seated while waiting, so that they may not have to wait long, and when their time comes may talk freely to the clerk where they may not be overheard. The physical examination is done quickly and courteously, and those who fail are given advice and suggestions as to measures to be taken to put themselves in shape at a future time. The applicant is told the rate that he is going to receive at the time of employment. By all means he is to be dealt with courteously and politely all the way through. There is an analysis of quits and discharges, the reasons for which are obtained, and the worker has free access to a court of appeal where he may air his grievances. In a great number of instances action has been taken so as to appease his feelings, and in a number of other cases his transfer to other departments has resulted in successful retention. Many cases have been found to be the result of a misunderstanding, and the man has been returned to his old position. During employment the individuals are followed up both inside the works and at their homes, in order to determine their living conditions and ascertain their particular complaints. Discharges have been followed up in order to secure evidence as to the real cause in order by analysis and rectification to provide against recurrences. In many cases it has been found that a visiting nurse may well supplement the hospital which forms the first aid to the wounded, and from which perceivable returns may be had. It is through "Hiring and Firing" that the unemployment problem is to be solved in addition to the question of maintaining the physical condition of the human element up to the maximum efficiency at the point of the tool.

The vacation question is one that has a large bearing in this connection. Formerly, before the club and athletic field, the annual picnic was the beginning of the vacation movement. With the advent of social development work within the plant, the annual vacations have been extended in length and scope so that now-

adays the general trend is to secure a month's vacation without reduction in pay to employees in general, in which the Government has taken the leadership. Many industrial plants now give an annual vacation to their employees, which is deemed of value in maintaining the personnel in the right spirit and condition, but it has been necessary in many instances to educate the employees and assist them in being able to enjoy a vacation. One instance is cited of a working girl whose company gave her a month's vacation, but who preferred to work as she said she had nowhere to go and could not afford to remain anywhere outside the plant, and had no companions with whom to occupy the vacation period.

Modern managers have not only endeavored to accord the vacation privilege but also to provide places to go to, and means to enjoy the privilege. The great Department Store of William Filene Sons Company of Boston is one of the most advanced companies in the application of welfare work, and while it does not provide its saleswomen with a summer lodging, it grants them leave and facilitates their own management of such a place near the beach at a summer resort, where the girls are enabled to have a month's delight and play during their yearly vacation. There are other firms who have gone further and provided such facilities for the enjoyment of their employees.

The modern idea has carried the welfare movement to the homes of the workers, and it is deemed to be essential that the personnel must be happy and comfortable at home in order to produce the best results in the shop. There are corporations that have laid out their whole plants embodying these facilities of welfare work, as well as neighboring villages where the homes have been made correct and proper throughout, for the occupancy of their workers. Model houses have been so built with arrangements to purchase them on practical terms by the men. Model towns have been run by the workmen and workmen's committee, an example of which is Vandergrift, Pa. The factory in its facilities and examples, followed to the home correctly built and established, furnishes the opportunity for the management to impose training by inducement not only to the workman to keep clean, to enjoy play, to practice thrift, and to improve in his trade, but also to lead the home life under similar and proper conditions.

A celebrated instance has been cited where the management provided houses for the workmen containing bath tubs. After a belated follow-up examination as to how the men were living, there was revealed a bathroom that was being used as a coal bin, with the bath tub full of coal. Workmen must be educated to the use of facilities to which they are not accustomed before any attempt should be made to force them. They must be led to adapt themselves to the habit and surrounding customs incidental to the daily life of the workman body in general. The management must contribute dressing rooms, wash bowls, soap, towels, showers and other facilities necessary for the employees to take advantage of the training. It is said that good homes make good workers, and many a good man has been queered by poor conditions at home. It is Mr. Charles M. Schwab who has stated that high quality on the part of leading officials is dependent in great measure upon

the disposition of the wife, which carries the home problem to its extreme application.

Collective insurance has recently been invented, and is now sold by the insurance companies to large corporations as a means of binding the interests of employer and employee more closely together with a view to reducing the labor turnover. The idea is for the corporation to take out insurance upon its employees as a whole, and to make each employee a party by permitting him to bear a certain portion of the cost with certain easements whereby he may retain his investment by paying the corporation the proper amount in due time, which is rendered altogether equitable and practicable. One of the insurance companies calls it "Co-operative Insurance and Pension System," and the William Filene Sons Company of Boston has adopted it. There is no doubt merit in the idea, as it is obvious that the problem can be worked out so as to permit the corporation to carry that insurance for its employees which the state may or will ultimately require, and the pension system for employees is now a moot question and will no doubt be brought to the fore at some future time, perhaps sooner than is now indicated.

Certain corporations have established a printing press and published a weekly journal for the uses of the men, in which all sorts of personal mention is made and prizes offered and announced for suggestions by workmen to improve the output or methods in any part, and the subject-matter is presented in such an attractive way as to make the workmen feel that they are a real part of the establishment and of the community at large. Through the medium of such publication the committees, and games, and scores are announced, and there are frequently prizes offered the wives and children of the workmen for suggestions, as well as other cooperative work. Undoubtedly such a publication binds the interest of the employees together in all the cooperative, social and welfare work of the establishment.

Welfare work is the most direct clue to the reduction of the labor turnover in the individual plant. Ida M. Tarbell, in her "New Ideals in Business," is authority for the statement that "Five years ago the Clothcroft Shop of Cleveland, already one of the best working places in the town, was hiring 1,570 workers a year to keep up a force of 1,060. The manager, Richard Feiss, undertook to organize it on a scientific basis, and the result is that more work is being done to-day by 20 per cent fewer people and the labor turnover has fallen 66 2/3 per cent. At the Ford Motor Works, in December, 1912, 3,594 of the 5,678 men hired turned out to be 'floaters,' 'five-day men,' as they are called. A month after the profit-sharing scheme was announced, the new practices in fitting men to their tasks installed, these 'floaters' fell to 322."

Analysis of the conditions on the whole has revealed that, and the writer fully believes it, the bonus system of payment is responsible in the greatest measure for the reduction of floaters, but that welfare work and scientific analysis extending far beyond the workshop are necessary elements towards steadying the job. Tarbell says:—"Four years ago Henry Ford, then employing some 12,000 men, was told by an investigator that he had set loose in his plant to find out what, if any-

thing, was wrong, that he was hiring 60,000 a year. He did not believe it. His partners did not believe it. The general superintendent hotly denied it, but their own figures proved it beyond dispute." Only a few months ago that conservative body, the National Association of Manufacturers, listened to a paper on floating labor, the result of unusually careful investigation. It showed that in a group of twelve factories perhaps slightly above the average in conditions, it had been necessary to hire 42,571 men to keep up a force which at the beginning of the period considered was 37,274 and which had increased by but 6,697. That is, six and one-half times as many men were hired as the increase demanded.

W. A. Grieves, of the Jeffrey Manufacturing Company, who conducted the investigation of floaters referred to above, has with his colleagues worked out a system of handling men which has reduced their labor turnover by about 60 per cent, an annual saving in the case of this particular shop of probably $50,000. If the twenty firms which Mr. Grieves found hiring 69,000 men to keep an average of 44,000 had applied his methods they would have hired only 27,600 and would have saved $1,760,000. What the 41,400 hired and fired would have been saved no man can compute. The German-American Button Company of Rochester, New York, claims that in the last few years new methods of handling their force, methods carefully planned and thoroughly and cautiously applied, have reduced what they call the "exchange of employees" 40 per cent, and they expect to reduce it still further. In four years the Joseph Feiss Company of Cleveland reduced its labor turnover by 80 per cent.

The application of shop science in finding work for the old and the young, and putting them at that for which they are best suited, supplemented by the welfare work incidental to the athletic field and the hospital and the operation of "Hiring and Firing," has been augmented by examples of employers who undertake to find employment for their labor during their idle periods. There are examples of firms who have regulated their output so as to keep a steady force and have so managed their custom and their orders as to make it subservient to the policy of maintaining steady work for its men, which of course is not always entirely possible. No doubt much can be accomplished through scientific analysis of the particular problem. Recently the States have come to the aid of employers and have instituted free employment offices. Tarbell states:—

"Wisconsin in the year ending June, 1915, received 52,568 applications for work and 31,095 requests for help from employers. They secured something over 22,000 positions. In the year ending June, 1916, the applications for work were a little less than 50,000, the requests for help something over 50,000, the positions secured 33,234. For over twenty years Germany has been handling her laboring men and women in this intelligent and humane fashion. Each state in the empire has fifty or more labor exchanges. Each capital city has an exchange which acts as a clearing house for the provincial exchanges. Work is found somewhere

through the ready means of intercommunication for every worker. A million or more men and women are placed every year by this organization. In the United States, January, 1915, this power was given to the Department of Labor, that is, to assist workmen in finding employment. The United States has been divided into eighteen distribution zones, each zone with its headquarters and sub-branches. The last report of June, 1915, gives 79 distribution offices. In the first year over 90,000 persons applied for information, and nearly 12,000 were directed to employment. This is the first start towards handling of the unemployed."

At the Fore River Shipbuilding Corporation the labor turnover between March, 1916, and March, 1917, resulted in the employment of 8,000 men in order to secure a permanent increase in the force of the men of 300. One of the great shipyards has recently employed an expert on labor conditions to represent it in cooperating with the various branches and distribution offices of the Department of Labor above cited in order to secure the required employees under conditions due to stress of war.

I have named this chapter "Welfare Work," as it seems to be the best term available to indicate the desired meaning, although it is admittedly defective. Mr. A. L. Filene prefers to call it "Good Business," which of course it is, but those words if used would not be the proper clue to the subject-matter involved. The officials of the Fore River Shipbuilding Corporation waive it away as a matter of course and classify it with such essentials as modern plumbing, etc. These remarks are merely to indicate the light in which the question is held by those who are among the leaders in these problems, but there are many industries that have not yet awakened to all the possibilities, and to whom no doubt there will be something new in this discussion. The great shipyards of America will no doubt develop along broader lines in the future than they have to date, as there is always room for improvement.

Mr. Frederick W. Taylor, in his work on "Shop Management," has stated with respect to welfare and paternalistic schemes, involving cooperative experiments in profit-sharing, that—

"Cooperation, or profit-sharing, has entered the mind of every student of the subject as one of the possible and most attractive solutions of the problem; and there have been certain instances, both in England and France, of at least a partial success of cooperative experiments. * * * Cooperative experiments have failed, and, I think, are generally destined to fail, for several reasons, the first and most important of which is, that no form of cooperation has yet been devised in which each individual is allowed free scope for his personal ambition. * * * The second and almost equally strong reason for failure lies in the remoteness of the reward. * * * Other and formidable difficulties in the path of cooperation are, the equitable division of the profits, and the fact that, while workmen are always ready to share the profits, they are neither able nor willing to share the losses."

The writer has introduced the above as bearing upon Mr. Taylor's contention that the true solution lies in the application of the bonus as a stimulus under scientific management. The writer believes that the application of the bonus or premium has more than any other one element been instrumental in producing the present high state of excellence in the output and the rewards of American industry, but that it is not the whole story. Undoubtedly, paternalistic, cooperative, and profit-sharing schemes in a large sense have had an influence in a general way similar to welfare work; but the application of welfare work, as described in this chapter, would seem to be as essential in the maintenance of the men as Mr. Taylor's mechanisms relating to the tool, and both would seem to be indispensable. I realize that Mr. Taylor in his wonderful work devoted his attentions mainly to the tool and to the mechanical conditions of the shop, and merely assumed the proper condition of the men with such scant mention that his humane attitude was misunderstood and widely questioned. It was obvious to me that his rest periods and his arrangements for the elimination of fatigue took into account a real consideration of the human element; but it is nevertheless true that he left for others the development of that side of industry which provides for the welfare of the men in such ample measure as to leave no room for doubt or dispute as to its reality or its worth.

THE SHIPYARD OF TO-DAY.

It is not so many years ago that the writer had his first duty as assistant naval constructor at a certain private shipyard, where the then scenes of comparative disorder and dirt were in strong contrast with the present-day system of order and beautification at the same plant. During the last eight years as superintending constructor at the Newport News Shipbuilding and Drydock Company and the Fore River Shipbuilding Corporation, there has been opportunity to observe at close range the growth and development of the principles and mechanisms of industrial management as they have appeared from time to time. In one great shipyard the welfare work was directed mainly to the baseball field on the one hand and the indoctrination of the negro population on the other, the latter by means of speakers and contributions to Sunday-school and social work, having for its purpose the captivation of the young by their elders, in fixing the real responsibilities of life among such employees as rivet heaters, for example, upon whose constant attendance the continuous operation of gangs of workmen depended.

In more recent times, another one of the great shipyards has inherited on the one hand the science of shipbuilding as developed by the shipbuilding fraternity, and on the other hand those ameliorating mechanisms of industrial management that have come from the fullness of experience of the Bethlehem Steel Company, which is the case of the Fore River Shipbuilding Corporation. It may be discerned that the novelties introduced through the medium of the Bethlehem Steel Company have consisted mainly of a particular application of the bonus system applied within the workshops on the one hand, and the welfare work in various

degrees as described under that heading in this paper. The beautification of the plant has taken place, there is system and order and cleanliness throughout the grounds and the shops and the grounds have been beautified with flowers and grass. The buildings have been made light and sanitary, and the proper temperatures provided for; and toilets, washrooms, dressing rooms, restaurants, and other essential facilities have been supplied.

The outlay of the plant is methodical and systematic for transportation and travel purposes, the organization follows the correct lines, there is the committee system among company officials and among foremen and workmen, to a very high degree. There is indoctrination through the committees, which reaches not only the work of the plant but also the social welfare work, which latter is up to date as far as attainable under the present limits. There are suggestion boxes and rewards, there is an athletic field and clubhouse with its baseball, cricket and other playgrounds, its target range, its bowling alleys, its reading rooms, its dance hall, its employees' band and glee club, and other facilities for social contact among the workmen and their neighbors and friends. There is the modern employment bureau with its experts attached, its committees for hiring and firing, its hospital, its medical officer and supplies for first aid to the injured. There is its monthly publication, containing twenty-odd pages of news about the employees and company officials and their doings, and incidentally carrying educational inserts in and between the lines, which affect the various branches of welfare work within the workshops and without. There is the employees' cooperative store, and its committee in control of same, which sells goods to employees at low prices.

There are altogether about two hundred and fifty committeemen made up of company officials and workmen, who control the industrial and social operations of the plant, the club, and the auxiliary services, including "Safety First." Welfare work has been extended to the homes of the workers in an indirect way, by which the company has acted as a go-between and guide and has provided in itself a substantial and quasi-legal guarantee, connecting the home-builder and the tenant with each other, in the providing of suitable homes for the workmen in the neighborhood of the plant—built, rented, leased and sold by their speculative owners. The following quotation from the "Fore River Log" of August, 1917, describes this arrangement sufficiently, as follows:—

"In cooperation with the company's efforts to have its men locate in Quincy a number of houses similar to the above have been built near the Fore River Club House, and are for sale at from $3,200 to $3,300.

"The property is yours for a deposit of $100 or more. A cooperative bank and second mortgage will take care of the rest.

"About six thousand feet of land goes with each house and potatoes have already been planted on each lot.

"Two-apartment houses have also been built and are for sale or to rent.

"These houses have been built by E. A. Poland of Quincy."

Generally speaking, the shipyards of to-day have made great advances in the art of industrial management along modern and scientific lines, but there has been a great obstacle in view of the diversity of output and of the mechanical trades employed, which have not been susceptible of the application of any uniform rule. If it had been the question of the machine shop only, the Taylor system would have been a hint of the possibilities attainable, but there has been the paint shop, the smithery, the pattern shop, the spar shop, and all sorts of varying work; consequently, in proportion to the great diversity of the work and to the varying sizes and types of ships under construction, the difficulties of organizing management along repeat-work lines or along uniform methods of shop management have stood in the way of a very high degree of development under the conditions. It is nevertheless true that since the educational effect of the Taylor campaign all the shipyards, as well as the other industries of the country, have greatly profited; and an examination into the desks and pigeon holes in the plant, especially around the machine shop, will reveal more mechanisms of Mr. Frederick W. Taylor and his adherents than any of the employees or officials would be willing to admit frankly.

The great shipyards, or some of them, apply straight piece work, and group piece work or contract work, to the hull construction work outside the workshops generally. Within the shops straight piece work and bonus, or premium work, is applied. In bonus work the men are allowed a certain number of hours upon a given job, and are given a premium of 50 per cent of the hours saved at their daily rate, being guaranteed and paid their daily wage whether a bonus is earned or not. Such a bonus system is in vogue in the pipefitters' shop, the electrical shop, the ship carpenters' shop, the joiner shop, the sheet metal working shop, the machine shop, and the riggers' shop. Group piece work, or contract work, is in use in the blacksmith shop, the paint shop, the boiler shop, the plate and angle shop, and the outside shipbuilding construction departments. Straight piece work is used in the pipe shop, the brass foundry, the plate and angle shop, and the outside shipbuilding construction department.

The machine shop of a modern shipyard, as compared with the other shops, is susceptible of the best application of the bonus system of payment, whereby the essence of the Taylor system is attained through different mechanisms than those used by Mr. Taylor, but leading to similar results, and from which all unnecessary experimental features have been eliminated. In other words, the principles and purposes elucidated by Mr. Taylor are obtained through other and more direct means, by substituting thinking and principles in lieu of tickets and mechanisms as far as possible. Under such an arrangement, the main machine shop of a large shipyard may be subdivided into a number of departments each under a leading man, who does the work of a gang boss as well as that of several other of Mr. Taylor's bosses for that department.

Each department may have a workboard or a dispatch board, as Mr. Taylor or Mr. Emerson would call it, respectively, and said workboard would carry all the

job cards for the machines of that department. The departments might be conveniently arranged to include as follows:—(1) All machines on the main floor except drills, (2) all drills on the main floor and lay-out table, (3) brass gallery, (4) lathes and steel gallery, (5) tool-room, (6) shapers, millers and turbine-bucket machines, (7) millwrights and repair men, (8) hull assembly, (9) turbine assembly, (10) submarine reciprocating engine auxiliaries. Each department containing a sufficient number of machines may have a blueprint bearing the plan of location and numbers of machines for facility in routing and assigning numbers to jobs where the charges are on the "machine-rate" basis, as should be the case. The boss or leading man in charge of each department is the manager for that department, and provides the jobs for the men, the job cards, does the routing and supplies the materials and tools, and has messengers and helpers as may be necessary to that end. He is the gang boss, the speed boss, and the inspection boss combined, as well as disciplinarian in part as assisted by the shop foreman. The speed boss is stationed in the main office of the foreman, being the man who possesses the Taylor information upon speed, feed and depth of cut, and upon tools, machines and materials. There is a repair boss who maintains the machinery and belting in proper condition, without much science on belting other than the feel of the hand and the standard output of the machinery, no belt bench or elaborate record-keeping being available as far as information goes.

The difference between a machine shop that has never had the belt bench and one that has is that neither uses it constantly but both determine the conditions by the feel of the hand and the known output of the machines after the attainable units of work are determined. The principal difference is that the one with the belt bench and equipment has actually established their minimum units scientifically. The numerous above-cited leading men or bosses in charge of departments are supplemented by a highly organized central office under the shop foreman, who administrates through a number of assistants the paper work necessary to keep the dispatch boards supplied with jobs and tickets and returns of the charges against the various jobs. The job cards are so arranged as to show progress, through the copies variously issued and variously returned at the different stages; and without going into any further detail, it may be said that the Taylor system is truly at work through other mechanisms, and has been reduced to its lowest terms by the elimination of unnecessary experimental features and the substitution of a much greater number of foremen, who in all probability abridge many mechanical mechanisms and paper services that a certain class of efficiency engineers would no doubt insist upon.

To establish the machine rate for overhead charges (which has only been found practicable in the machine shop, and may possibly be extended successfully in the blacksmith shop), it is desirable that the machines should be divided into classes, say six for example, each class containing machines of a certain size and value to which is assignable a uniform machine rate for all machines within a class. The machines may be divided also into a number of types, say ten for example,

each type indicating the style of machine, as millers, lathes, planers, slaters, shapers, drills, vertical boring mills, horizontal boring mills, and cold saws. Every machine would therefore be numbered, which may be done by the use of four figures, in which the left figure would indicate the type, the second figure from the left the class, and the two figures at the right representing the individual machine number. Thus a machine numbered 8,123 would indicate type 8 (horizontal boring mill), class 1, meaning, bearing the largest machine rate, or $3.60 per hour, being machine numbered 23 of that heading.

The machine rates are established embodying the values under that heading.

Let us say that the machine rates for Classes 1, 2, 3, 4, 5 and 6 would be established at $3.60, $1.80, $0.90, $0.45, $0.30, and $0.15 per hour, respectively. The highest rates are made to fit the largest and most expensive machines in Class 1, and the lowest rates those of the smallest and least expensive machines in Class 6, and the intermediate rates in their proper proportion corresponding to the values set for the intermediate classes. These rates would be variable and relative, always maintaining the ratio inversely of 1, 2, 3, 6, 12 and 24. That is to say, if the application of these rates to the shop overhead had to be increased or reduced so as to balance the actual shop overhead upon a sum total of the job charges, it should be done by adding or subtracting proportionally to the above figures, the adding or subtracting of one carrying with it a like application of all the others. That is to say, if 1 cent should be added to the 15 cent rate for Class 6, to Classes 5, 4, 3, 2 and 1 would be added 2, 3, 6, 12 and 24 cents, making the machine rates $0.16, $0.32, $0.48, $0.96, $1.92 and $3.84, respectively, and so on. It is thus unnecessary to determine exactly the machine rates, and the problem may be abridged as above by a process of trial and error. The overhead charges in a given shop are determined from actual expenditures. In estimating the machine rate by means of the above-cited figures, it may be found less or greater than said actual expenditures, and the machine rates must be increased or reduced accordingly, which process is repeated from month to month to attain the nearest approximate results.

Modern shipyards have been in the same category with other American industries in the matter of cost accounting, generally speaking. Mr. Edward N. Hurley, ex-chairman of the Federal Trade Commission, in an address before the Boston Commercial Club in March, 1916, said:—

"Only 10 per cent of our manufacturers and merchants know the actual cost to manufacture and sell their products, 40 per cent estimate what their costs are, and 50 per cent have no method, but price their goods arbitrarily. Most of the manufacturers and merchants who do not know what their goods cost are basing their selling price on what their competitors sell for, and with only this knowledge for a basis they are frequently cutting prices and demoralizing the industry in which they are engaged. There were over 22,000 business failures in the United States last year; more than 20,000 of them were small concerns. We all know that a large percentage of business is run at loose ends, haphazard and without the pro-

prietors really knowing at any time how they stand or whether they are making a profit or a loss."

The above quotation is from the June, 1916, number of the *Engineering Magazine*. In the September number of that year, Mr. Hurley further stated that—

"Statistics show, also, that the percentage of business men who do not provide for depreciation is very large—running over 50 per cent—and this is undoubtedly one of the big reasons for our high business death rate."

About five years ago I asked a representative of one of the great shipyards what were his rates of depreciation, and he replied, "We never have depreciated." As a matter of fact the said shipyard had been operating nearly a score of years, and was depreciating rapidly all the time, but no depreciation had ever been charged off. It is only within the last year or so that said shipyard has begun to charge off depreciation, and indeed such action was a forerunner of the present cost-plus-percentage contracts for ships of the Navy, wherein the incentive to charge off depreciation and other unexpected burden has indeed arisen in some quarters. To depreciation, as well as to other legitimate charges, is to be added 10 per cent profit under such contracts, and there is now no question but that the shipyards of the country will charge off depreciation, the amount not being a question as to whether enough has been charged but rather as to how much it may be possible to persuade the Government to allow.

In cost accounting, the last word of course has not been said in the shipbuilding industry, no more than in the state of development of shipyard management, but it may also be said, without comparison of other shipyards with the details of which the writer is at present unfamiliar, that the Fore River Shipbuilding Corporation has inherited the cost accounting methods of the Bethlehem Steel Company, and if all the shipyards of the country have benefited to a like extent from the fullness of American industrial experience, there need be no alarm as to the state of perfection in which the cost accounting systems of American shipyards find themselves to-day. There is much to be said and little to be criticised on that score, especially in view of the principles and larger phases with which this paper undertakes to deal.

As to shipyard management in general, a few years ago an address was made by Hon. William C. Redfield, just before he became Secretary of Commerce, to the Society of Naval Architects and Marine Engineering, which held out the possibility of vast improvement on the part of shipbuilders, and which the writer suspects rather got some of them by the ears. At that time there was much more to be said in corroboration of Mr. Redfield's view than is the case to-day, as great advances in the art of management have been made between the date of that speech and the present day, but I dare say the shipbuilders would be willing to admit that there is still much room for improvement.

DISCUSSION.

THE CHAIRMAN:—Captain Roberts expects many of you gentlemen here to read this treatise very carefully. That is the least appreciation we can show the author, to give it careful reading and study. There are a number of prominent experts, all of whose names are almost household words in industrial management literature to-day. I do not know in just what order they would like to speak. I will call on Major Gilbreth.

MAJOR FRANK B. GILBRETH, *Visitor:*—I suggest that I come last, so that you can all go home when I begin to speak. I will not be like Joe Cannon, who always wanted to be last to hold the crowd, but I have a number of lantern slides to accompany my remarks, and I think they would best fit in at the end of the discussion on the paper.

THE CHAIRMAN:—If agreeable to you gentlemen, I think it would probably be well to have me limit the time a little, and you will not mind my telling you when you have taken about your share of the time. I will first call on Mr. L. P. Alford, editor of *Industrial Management,* to open the discussion.

MR. L. P. ALFORD, *Visitor:*—I wish I had the same excuse as Major Gilbreth has to be put last on the list of those who are to offer discussion. The chairman has expressed appreciation of the work that Captain Roberts has performed in studying the historical development of industrial management and in preparing this address, which will undoubtedly live as an analytical study of what has been done throughout the period of establishing management principles; because of that historical side, I will refer to just one thing and let my discussion end there.

On page 163 of the report reference is made to a committee of the American Society of Mechanical Engineers which was appointed in 1912 to study industrial management as it was practiced at that time, and to present a report under the title "The Status of Industrial Management." It so happened that I was one of the members of that committee. On page 163 Captain Roberts also touches upon the term "Labor-Saving Management" and says that one purpose of the activities of the American Society of Mechanical Engineers' committee was to find a new name to take the place of "Scientific Management." I am sure Captain Roberts will let me correct that statement. The committee was appointed to make a study of the "Status of Industrial Management," and, entirely apart from the rendered report, to harmonize certain opinions and tendencies held by members of the American Society of Mechanical Engineers. That was the principal purpose of establishing that committee and preparing its report.

The committee in its study was struck by the analogy which existed between labor-saving machinery and labor-saving management. Although the parallel was not worked out in detail at any of the sessions of the committee, still it seems to me there is such a parallel which is worth just a moment's consideration. I have prepared this in skeleton form, using the familiar double column. The comparison is as follows:—

Labor-saving Machinery.	*Labor-saving Management.*
Developed from three great British mechanical inventions made in the last half of the eighteenth century.	Began in the American machinery building industry in the last quarter of the nineteenth century.
Was bitterly opposed and even fought by hand workers who in numerous cases destroyed the machines that they feared.	Is opposed to-day by organized labor which in some cases has fought by means of the strike, and for several years past has influenced Congress to pass prohibitory legislation as regard Government work.
Is fallaciously thought by workmen to injure them by taking away their means of earning through skilled hand work.	Is believed by organized labor to be a means of oppression that only increases the profits of the manufacturer and strengthens his strategic position in industry.
Ushered in the manufacturing system and changed the business of the world to industry.	Promises to extend, strengthen and improve industry and even correct some of its evils.
Brought recognition of a group of now universally accepted principles as: the division of labor; the adeptation of labor; the transfer of skill.	Has already brought the declaration of a number of regulative principles as: the scientific study of all industrial problems; the setting up of standards; the recording and use of experience; the selection and training of the worker; the promotion of human relations in industry.
Was first designed to function only; later to be operated with ease, convenience and safety.	Was first applied to increase production only, but rapidly began to improve the essentials of working conditions through studies of fatigue and the like.
Has been going through an evolution in the standardization of proportions during the last half century.	Has insisted upon and practiced the standardization of methods from the start.
Has brought these results: great increase in human effectiveness industry; great increase in production of articles of use; increase in human comfort and leisure.	Brings, where properly applied: increase in human effectiveness; increase in production; shortening of hours of labor; improvement in working conditions.

Naval Constructor Roberts:—I should like to reply to Mr. Alford at this point. Modern management is of course labor saving in the larger sense that he refers to. It is to be remembered, however, that at the time the committee adopted the name "Labor Saving Management" in lieu of "Scientific Management," the Taylor system was then the "Scientific Management" understood. What I meant to convey was that to call the Taylor system by the name of "Labor Saving Management," was defective in that it begged a question highly in dispute. It is now a settled question that the Taylor mechanisms can be, and in certain cases have been, carried too far and extended beyond the limits of maximum labor saving, by the introduction of corresponding overhead costs that might better be

dispensed with. Besides, the question is so involved as not to be obvious, as in the case of labor-saving machinery. Consequently it seemed to me at the time that, as names go, it was not altogether apt. Time has verified my then view that it would not stick. So much for the name. I am glad that Mr. Alford has amplified the substance and given us so much valuable data on the subject.

Mr. H. L. Gantt, *Associate:*—Mr. Chairman and gentlemen, I did not come here to make a speech. I want to say this, however—Captain Roberts' paper is very important and very interesting from a historical standpoint, but during the past two or three years, since the breaking out of the great war, things have so changed as to make obsolete almost everything that was done before that time. We were concerned then largely with time study and a lot of details that I submit have now shrunk to almost insignificance, compared to the great problem of harmonizing industry.

In listening to some speeches by the members of the British Munitions Board the other night, in which they described what had taken place in England, I was particularly struck with the statement they made as to how the idea of business for profit had been absolutely given up under the emergency of the great war for the principle of business for service. During Mr. Taylor's activity, and up to the time of his death, business for profit was the great aim of all of our business. We hardly realized the other idea. Within the past two years, though, it has become perfectly clear that we must harmonize our industries in order to give service to the community. That is a very different standpoint from business for profit. There was one time when we did not know the difference, but now we see it very clearly.

The real problem of business, the real big problem, the scientific problem of business and industry, is how to harmonize business for the service of the community. The individual workman in this country is actually more efficient than the individual workman in Germany. Some of you may doubt that, but I was over there and studied conditions and came to that conclusion. Moreover, the individual workman in this country in 1913 turned out more value of product per day, based on wages received, than was the case in Germany, although the German get only two-thirds the amount of money paid the American workman; yet the efficiency of the German organization, as a whole, is enormously greater than our organization, because in Germany an autocratic military authority has forced industry to cooperate. We have no autocratic military authority to force industry to cooperate in this country. We must have sense enough and patriotism enough to make our industries cooperate without that force.

The Chairman:—The next speaker on the list is Mr. C. E. Knoeppel.

C. E. Knoeppel, *Visitor:*—Mr. Chairman and gentlemen, I have not had an opportunity of thoroughly reading the paper by Captain Roberts, but there is one fundamental feature which occurs to me, as it may have occurred to a great many of you people here—now that we have it, what will we do with it? Mr. Gantt is absolutely right. We are no longer in the same position with regard to scientific management as we were five years ago. We cannot think in the same terms, and there must be some use for the unusually excellent work which has been produced by Captain Roberts.

In attempting to analyze conditions, we oftentimes have to use the lessons of the past, and in doing this I have become convinced that in the life of individuals and nations there

are four cycles—first, conflict; second, development; third, refinement, and fourth, retrogression, the last meaning the beginning of a new cycle.

That is true in the life of nations—take the Napoleonic wars, our Civil War and the Franco-Prussian War. This was the conflict period. Immediately following came a world-wide reconstruction period or development period, followed by a period of refinement up to 1890, when the cycle of retrogression set in which ended in August, 1914, when a new conflict period—the great war—started. Out of the present war something better will come—development and refinement.

Take scientific management. The conflict period was that period during which this nation emerged from an agricultural to an industrial nation. Then came the period of development, the excellent work of Fred W. Taylor, the pioneer in the management field; the definition of "Production Engineering" by James Newton Cunn; the accounting work given to us by A. Hamilton Church; the works of Mr. Gantt, Mr. Barth, Harrington Emerson and others.

We are now, therefore, face to face with the refinement period, which will be influenced to a great extent by this great war.

It seems to me that the paper by Captain Roberts is very timely and useful, as it is a history of the developmental period. The men in the movement, younger as well as older, are not going to live forever, and what we do with the movement in this refinement period will be in the hands of the younger generation, and they can keep from stubbing their toes many times by using wisely the lessons of the past.

The results of the developmental period outlined in this paper will give a man a great many things to ponder over and will enable him, in the refinement period, to refrain from making the same mistakes that were made in the developmental period.

The keynote in the refinement period will be human relations and human adjustment, on the theory as you develop organizations you develop men, and as you develop men you develop organizations. The conflict period was one of transition; the developmental era dealt with material things, while the refinement period will deal in terms of humanity.

The Chairman:—We will now call on Major Frank B. Gilbreth.

Major Gilbreth:—Captain Roberts's paper is a masterly contribution to the literature of scientific management, and this Society is to be congratulated upon its presentation. His remarks regarding the field of psychology in management would alone make the paper of importance, and should be read by psychologists, by managers, and by engineers, for there has been much too little general understanding of the interrelation of psychology and management, due to the two sciences seldom being taught in the same courses in our colleges. I congratulate the Society on having this paper as a part of its Transactions, and its dissemination will result in much national benefit. The countries abroad are thinking, studying and working along lines of greater elimination of waste by more scientific administration and cause many to think of the subject here.

There are, however, several statements in the paper from which we differ. These usually are expressed as opinions, and we oppose to these the results of actual measurements. In other words, Captain Roberts believes, as he has said, that "management is an art and not a science," while we believe that management is a science in so far as it is based on accurate measurement, and that it is being so based each year to a greater and greater degree.

As typical of the viewpoint of Captain Roberts with which we differ, we might mention his statements concerning our micromotion study, which he regards as an interesting, but apparently not essential, development of management. Now micromotion study is not merely a refinement; it is a fundamental. This is shown in the laws relating to methods of least waste in learning and performance which we have been able to discover and prove.

Regarding the question of whether or not this method could "equal a personal investigation under the naked eye," we still state that with the Simultaneous Motion Cycle Chart,* and the film from which it was made, and chronocyclegraphs, one is able to make a much more comprehensive analysis of the method used and its improvement than one can "with the naked eye." This has been proved time and again; in fact, there are cases on record where cycles have been reduced more than 50 per cent by these methods after experienced time study men with stop-watches have made a reputation for the savings on the same cycles. Not only do these methods of our motion study "convey all the methods and surroundings" as well as the naked eye, but better, because the motions and methods of surroundings and conditions that obtain can be recorded truthfully and examined at leisure without the confusion and distraction that accompany all work. Not only can they "convey to said absentee all that could be available to the eyewitness," but they can and do convey more.

The Simultaneous Motion Cycle Chart records and calls attention to deviations from class, and such exceptions, either less or more desirable, can be reinspected for determining the deviation by examining the film.

Moreover, the evidence of the much praised "naked eye" is no more reliable as a witness than is the opinion of the performer of an activity as to the methods he is using.

As an instance of this we are fortunate in having the "still" picture of Harry Varden, which is a part of the admirable paper of Captain Roberts. We have taken pictures of Gil Nichols, James Barnes and Francis Ouimet, all champions and famous players, and we do not find any picture in the consecutive snapshots of more than eighty pictures per second of the moving picture camera that corresponds to Mr. Vardon's pose. We suspect that this picture does not represent what he really does. We think it is posed in the way that Mr. Vardon makes his "finish of swing" (see Plate 34), and right here is the gist of the whole thing. The accurate photographic records, including data as to both the time and the space that the activity recorded occupies, are infinitely superior to any individual's opinion, be he performer or observer of the activity.

The micromotion records are supplemented by chronocyclegraph records.

Our first cyclegraph was made in 1898, but it was not used commercially until 1912. The cyclegraphs are reexamined often, to formulate and prove laws of efficiency and least waste. In fact, all cyclegraphs are useful in comparing with other movement work. They never cease to furnish data. Their records also prove how easily and completely the eye is deceived. For example, though champion golfers insist that the head does not move, that the head of the club goes up and down in the same path in any one shot, and that the hands are the same height above the ground while addressing the ball as when hitting the ball, our records show how far these beliefs are from the truth.

We would call the author's attention to the fact that the golf example is no "surprising exception." The same thing occurs in the work of the surgeon, the typist, the bricklayer, the

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*See "Motion Study for the Crippled Soldier," N. Y. Section, A. S. M. E., 1915; and "Applied Motion Study," Sturgis and Walton, 31 East 27th Street, New York.

orthodontist, the baseball player, the machinist, the textile worker, the box-maker, the musician, and in all kinds of factory and office work.

It is here that the definitions of time study and motion study may help to make clear the difference between the two. Time study, according to its originator, Mr. Frederick W. Taylor, in "Shop Management," 1903, was the "study of unit times with the idea of determining the quickest time in which it (a job) can be done by a first class man." Now Mr. Taylor never did any motion study such as we know it. He cites as his best example of time study, selected three years after he retired from business to illustrate his famous "Shop Management" (Transactions of the A. S. M. E., Paper No. 1003, presented at the 1903 meeting), the work of Sanford E. Thompson, who, he states, is by far the best time study man. The "elementary time units" were elementary only so far as they were subdivisions of any operation, but were in no way subdivisions of a cycle of motions. Furthermore, the stop-watch can neither be pressed nor read to give the time of the sixteen subdivisions of a cycle of motions.

Now the definition of motion study is:—"Motion study is the science of determining methods of least waste." Some of the motions measured occupy less than the thirtieth of a second; the work of champion typists and other experts at keystroke vocations cannot be satisfactorily captured and recorded by photography in less than 100 pictures per second.

We believe that "Motion study," as we use the term, began in 1885. It progressed far enough in 1892 to have some of the apparatus for bricklaying patented, and to be awarded a silver medal by the Massachusetts Mechanics Association in the same year. In 1885 were discovered the great facts:—(1) That fast motions and slow motions do not and cannot occupy the same path or orbit. (2) That every worker has at least three sets of motions that are not alike, (a) fast; (b) slow; (c) demonstration motions.

Many facts have been discovered since, but the proofs were not generally accepted until constant intensive study developed the micromotion and chronocyclegraph methods of recording and analyzing motions.

But the important feature has been entirely missed by Captain Roberts, and that is the value of our methods in the "Quest of the One Best Way." The one best way cannot be discovered by any other method, so far as we know. The difference between the one best way of the one best workman known extant and the usual method is tremendous, and the total loss due to not having the one best way extant put within the reach of all workers is staggering when put in dollar and cents equivalent. When this difference is increased by comparing the one best way of any one worker and the synthesized best units of all best workers, the loss becomes the greatest annual loss known to man. It is greater than the fertile soil that is lost to the world yearly by being washed to the sea from the ploughed ground and fertile fields, greater than the loss from water running and falling to the sea without generating electricity; and there is no excuse at all for the loss except ignorance.

The best units from the best workers can now be truthfully recorded, captured and preserved for use to-day and forever. The method is not like the secret time study done by means of a stop-watch concealed in a note book. The errorless photographic micromotion records are available for the worker to see at all times. The worker may die; his method will live forever. The fame of the foremost is sure. He can contribute to the success and prosperity of his fellows more permanent value than can the millionaire.

We are on the threshold of a new era in education, mental and manual. The quest of the one best way is never ended. The improvements will be constant and cumulative. The

one best way is derived by measurement. Its data explain themselves. It is a mark to come to. Its improvements speak for themselves because they are accompanied by measurement in terms of relative and exact time, and relative and exact speed due to the photography of (1) time, (2) the cross-sectioned background, and (3) the workers, simultaneously.

Methods bad as a whole, yet possessing parts that have superiority, can be made of full value by inserting, by means of scissors and cement, those portions, however small, that are better than those displaced.

But our method does more than discover the one best way and make possible the dissemination of facts pertaining to the one best way to do many kinds of work. It teaches the underlying principles of motion economy. It teaches and habituates the workers to think in terms of the subdivisions of cycles of motions. This in itself makes motion study a source of gain even "when the job is not repeated." When we add to the results of motion study the results of applying its accompanying fatigue study we have surprising gains. The elimination of unnecessary fatigue alone will make possible a saving of more than $5,000,000 per day, if the inhabitants of the United States of working age will eliminate enough to equal ten cents apiece per day.*

We claim, then, not only that management can become and is becoming, to a greater and greater extent, a science, but that the application of accurate measurement to management is a paying proposition, and we have no doubt that Captain Roberts will agree with us.

Again I want to congratulate Captain Roberts on this most interesting and valuable contribution to the science of management. It is the most illuminating article I have read in many a day, and I want to congratulate the Society upon having a member who has contributed real knowledge to the cause that is going to help in the war of commerce and manufacture that will come after this war of powder and shell.

THE CHAIRMAN:—We will now hear from Mr. Polakov on this subject.

MR. WALTER N. POLAKOV, *Visitor*:—Mr. Chairman and gentlemen, the analysis of the principles of industrial management as presented by Captain Roberts reviews the early state of the art and stops where its real significance, as a social factor, begins. I feel, therefore, less compunction in pointing out those principles of industrial management which are left out of his paper than to discuss the presentation itself. The main, and perhaps the only fundamental, principle of industrial management is the scientific analysis of all factors and elements entering into the problem. Scientific management is but an example of practical application of Cartesianizm of Rene Descartes or the adoption of methods laid out by Francis Bacon in his Novum Organon to the solution of industrial problems. The radical distinction between the scientific and old style management is that the first bases its activity on accurately established facts, while the second is guided by opinions and traditions survived from the old régime.

What a remarkable increase of productivity, elimination of lost motion and other wastes was accomplished by those who judiciously applied these principles to their work is too well known to be here recited, but until comparatively recently all the efforts were concentrated on how to make workmen efficient. The turning point in the movement can be linked with

*See "Fatigue Study," Sturgis and Walton. Also "Fatigue and Efficiency," by Josephine Goldmark, Russell Sage Foundation, New York City.

the series of lectures by H. L. Gantt at the Sheffield Scientific School in 1915, when it was publicly announced, for the first time, that far greater industrial wastes are due to the inefficiencies of managers and financiers than to the poor methods or soldiering of workmen. We had come to a realization that the efficient workman and most excellent equipment is of a very limited value unless it is provided by good leadership. The bitter truth of this assertion, proved in countless cases, was particularly clearly demonstrated by the exigencies brought about by the world war.

While "efficiency engineers" were talking about how to save fractions of a minute wasted by workmen, the management cared little if half of the plant equipment remained idle, due to one cause or another. It was not generally recognized that to keep the plant idle cost money, usually a great deal more than to let the men stay idle. Somebody had to pay for the rent and all forms of overhead expenses or burdens, yet our financial structure devised vicious methods of accounting which distributed the expenses of non-use of productive capacity on the product. In other words, as I had shown at the last meeting of the American Society of Mechanical Engineers, the common practice is "to charge against the cost of product the cost of over-equipment and mismanagement, thus imposing on society the penalty for tolerating these conditions in the industries."

The greater the efficiency with which the working portion of the equipment is used, the larger is the burden imposed by the idle portion of the plant, and usually the remedy is sought in the advancing of prices of the commodities. Higher prices, however, soon overtax the purchasing power of society, and demand falls, leaving still more equipment in idleness.

Thus the analysis of the influence of the excess equipment brings forth a recognition of a new principle of immense importance: that if the cost of possession of the idle means of production were charged against the capital, not against the product, the result would be; (1) Stimulation of product; (2) decreased cost of commodities; (3) increased value of labor; (4) larger consumption and turnover.

While the actual suspension of the law of supply and demand on the market prices is caused by the commissaries of the fighting armies anxious to keep them in fighting trim, the truth of the above principle is rapidly recognized in this country, and several influential business organizations and banks recently proclaimed the supremacy of social service over the personal profits.

Closely related and intimately connected with these new problems presented to the industrial leaders follows another general principle—that the cooperation among the manufacturers, in order to be beneficial to society as well as to themselves, must be based on the apportioning and distributing of total volume of work to be done among the plants best fitted to fill one or another part of the work.

Scientific study of war orders clearly demonstrated that while one concern is falling back on its scheduled deliveries because of inability to do sometimes only a minor operation, another concern has extra spare capacity to do just this job, but is handicapped, perhaps, in some other respect, and so it goes.

Whereas the first principle is applicable within any one shop, the second calls for its success, for a controlling, coordinating organ. The Ordnance Department has taken this subject up.

Recognizing these new principles, industrial management ceases to be merely a dividend-grinding mechanism, as it was viewed heretofore both by its friends and adversaries.

Through these new functions it becomes a creative force, and, without its help, the organization of the new order of society—Cooperative Democracy—is unthinkable.

Recently we were forced by the grave war necessity to allow the Government to regulate business. We made this step towards a "State Socialism" as a transition phase in the great social evolution, chiefly because of the British experience. This lesson as apprehended by the *London Economist* is simply that the necessity created by the war spurred the European industries to an unheard of state of productivity, and now, after three years of experimentation, "it is becoming widely realized that we cannot go back to our old free, untrammelled individualism. We can no longer conduct business, each man for himself, each industry for itself, on the principle of the devil-take-the hindmost. Cooperation under state compulsion has shown us what might be achieved by cooperation under voluntary organization. Inefficient as is industry under government control and management, yet we have seen how very great was our frictional wastage before the war under our old free competitive method and system. The country, by mobilizing its man and woman power and directing it to one common purpose, has achieved results which are the wonder and admiration of the world. Five millions of men have been withdrawn from productive work and put to the most expensive and wasteful of all work, yet the country has carried on for three years, and the individual citizens have suffered less of hardship, even of inconvenience, than have the people in any one of the allied countries, or than have our enemies."

The new means worked out by industrial engineers, those of regulating the cooperation and distribution, have the chief aim in view—to produce the commodities cheaply and without restriction or limitation. The new method gives to an industrial engineer a powerful tool to crush an obvious danger which otherwise would have to be forced—a sweeping conspiracy to fleece labor and consumers. In this connection the *London Economist* predicts:—"Any attempt to achieve full efficiency in production and distribution which does not have as its paramount aim the cheapening of the product to the consumer will fail and deservedly fail, through the revolt of the consumer."

If we feel that "priority" and "price-fixing" are falling short of our expectations or ideals, we yet gladly agree that the anarchy of cleptocracy must come to an end. We cross the Rubicon, and the new principles of industrial management shall accomplish a stupendous task—to help shape the new industrial democracy.

The conception of the old school of industrialism was to produce the goods cheap and sell them dear. The leading men of this country now realize that the era of unearned profits is coming to its end, and the war for democracy spells that only he shall get who renders service to the community.

It matters little whether one is for or against scientific management. It spreads as the use of machinery, being a higher form of productive organization. One may disapprove its clumsy, unskilled, sometimes vicious applications, but its principles are as indispensable as ever-growing demand for the commodities. The new mode of production affects the economic foundation of society and as such the higher forms of engineering and economic conceptions are bound to reshape into higher form our entire economic and social structure.

The Chairman:—We have followed a different plan in connection with the discussion of this paper from what usually obtains, in that we have not extended a general invitation to anyone who felt the spirit move him to get up and speak. We have another paper to consider this afternoon. However, we can take a few minutes more on this paper, if any

one else wants to speak on this subject. If not, we will ask Captain Roberts if he cares to say anything in closure.

NAVAL CONSTRUCTOR ROBERTS:—I have some written discussions, Mr. Chairman, and with your permission will read an abstract from these discussions.

NAVAL CONSTRUCTOR WILLIAM J. BAXTER, *Member of Council* (Communicated):—The author of this able paper and myself worked together in a navy yard for some years. With his discussion regarding new construction work I am in general agreement, but to perfect this or any other system much time is required, and, to secure the best results for the management and for the employee, the workman must be well drilled and experienced in the various details of the system in vogue at the shipyard where he is employed.

I have much sympathy for those excellent workmen who are handicapped as they go from shipyard to shipyard, as the demands for their services vary, and find in each yard a different method of performing the work which will accomplish the same results. But, even in new construction work, close personal touch between the management and the workman is of the greatest value. All of us who have had responsible direction of the output of others know that the best results are obtained in the shortest time when the workers feel that they get credit for good work, and that their prompt response to a call for improved or increased output is recognized. The descriptions of Mr. Schwab's action on page 229 and of Mr. Otterson's action on page 176 bring out clearly the importance of personal touch.

I do not believe, however, that any of the described systems of management are efficient in urgent repair work, such as repairs to a crumpled bow, a damaged cylinder, an injured propeller, or damaged bottom plating. The management will, very properly, direct in a general way what items are to be renewed, what repaired, and what altered; but it is the skilled workmen on the job who ascertain and describe the specific details of injuries to be repaired and who suggest the best methods of making good each individual defect. That management is best which has rubber in its system, as well as steel and brass.

MR. DWIGHT T. FARNHAM (Communicated):—It is my belief that Naval Constructor Roberts in his analysis of the principles of industrial management has rendered a service to American industry comparable only to that service performed by the group of men of all schools of managment, who last May, sinking all professional jealousy, sat down in the rooms of the Western Efficiency Society and figured out a method of assisting in the production of the equipment necessary to the winning of the war through the formation of the American Society of Industrial Engineers. Since history began the worst enemies of any great constructive movement have been its ritualists. From the time of the Scribes and Pharisees the men who have done religion the most harm have been the narrow-minded within the organization—the men who have mistaken the form for the substance, the Evarras who have cried aloud in the wilderness—"Thus gods are made, and whosoever makes them otherwise shall die."

Unfortunately the demands upon the time of the world's greatest doers have very often been such that they have perforce been compelled to leave the interpretation of their acts to disciples whose loyalty has been equalled only by their lack of understanding. The monks in the middle ages who fought over the question of how many angels could stand at one time upon the point of a needle while the hungry starved at the monastery gates, were

simply prototypes of the arm-chair type of industrial engineers who fight about the exact sort of mnemonic system which is orthodox, while millions are wasted annually in American industry.

The man who realizes the situation, if he be an insider—regardless of the school to which he belongs—usually hesitates to attack the ritualists for fear of bringing his cult into disrepute, and the outsider is equally deterred because he hesitates to lay himself open to the easy and ancient cry of "sour grapes." A man, therefore, whose position is not open to misconstruction and whose opportunities to study the work of the various so-called "schools" thoroughly and dispassionately at first hand, has been unusual; moreover, a man who is in no way open to the charge of being "theoretical" from the men who style themselves "practical business men" is doing American industry a distinct favor when he discusses the work of the various industrial management schools in so eminently a fair and unbiased manner as Naval Constructor Roberts has done.

Not long ago I risked getting "hades from both banks" by entitling a book "Scientific Industrial Efficiency." My agreement with most of what Mr. Roberts has said is perhaps best and most briefly illustrated by a quotation from it.

"One evening when I was discussing the principles of scientific management with an engineer who is perhaps as thoroughly grounded as any man in the country, I endeavored to tabulate these principles. My friend watched me for a few minutes, and then with that dryness of humor which is the delight of all who are privileged to know him, remarked:—'Don't become a Methodist. They are all right in religion, but when an engineer tries to reduce what he knows to mottoes to hang on the wall of his office, he'd better drop engineering and take up preaching.'"

There is great danger in reducing knowledge to "rules of thumb," because once this is done the author of the rules, having once committed his belief to writing, feels that he must forever defend those beliefs, even as our political parties defend their platforms. As a result, the engineer who has once enunciated his beliefs is induced to seek always the facts which prove his contentions and to ignore all other facts. This leads to biased judgment and often to disaster.

The writer realizes this danger, but nevertheless feels it would be worth the risk, after quoting a statement made by Edward D. Jones, Professor of Commerce and Industry of the University of Michigan, concerning the source of the term "scientific management."

"The pure method of science is the original source of inspiration of scientific management. Very briefly and inadequately expressed, it is somewhat as follows:—

"1. The first step is to analyze a subject into parts, and to deal with the subject a part at a time.

"2. The second step is to proceed with the collection of data, in this analytical form, until it is certain that the record fully records the law of the subject, whatever that law may be; and further, until accidental errors and other variations due to chance are reduced to negligible or definitely calculable proportions.

"3. Third, the data are to be so arranged that they will be brought to bear as fully and clearly as possible upon the object of the study.

"4. An inference is made, or a new relationship discovered.

"5. The fifth and last step is to give to the new inference a thorough testing, by comparing it with known facts, to ascertain whether it is truth or error. If the new inference stands the tests, it is no longer considered an hypothesis, but a truth."

The scientific method, then, is *the* principle underlying scientific management. Various engineers have different methods of applying the principles and have enunciated their methods, each in the form that he believes is best calculated to explain his own application of the principle. These codes are necessarily somewhat vague because each particular business, nay, each particular department and operation, must be studied separately and the remedy applied which will insure the maximum operating efficiency of that operation, department and business, at all times. In doing this there is brought to bear on the problem all the knowledge of the workman, the foreman, the superintendent, the manager and of the engineer. The greater the knowledge of each, the more perfect the final result. The engineer is not a critic, but an expert in the art of organizing your forces for victory by the application of *the* principle and its elaborations. The tabulation follows:—

1. *Standardization* of Machinery, Equipment and Conditions.

2. *Routing,* insuring that the product is moving in the most economical manner with the fewest, shortest and least damaging moves possible.

3. *Centralized control,* including:—(1) setting standards of accomplishment; (2) scheduling, planning to attain these standards; (3) despatching, making sure, step by step, that the standards are attained; (4) stores and the material control, to integrate with the above, and so insure the presence of the right thing at the right time; (5) release of executives from details of operation by means of the exception principle.

4. *Analytical Cost System.*—(1) Graphic comparison of all important operations; (2) the ratchet principle, preventing the loss of an advantage once it is gained; (3) immediate returns, on all important operations, allowing the application of correctives in time to save the maximum amount of loss.

5. *Waste Elimination.*—Application of the scientific method to losses of every sort, insuring their sure reduction to the minimum.

6. *Staff Investigation* of All Problems of Administration, Sales and Manufacture:—(1) the Committee System; (2) harmony meetings; (3) development of specialists; (4) expert counsel.

7. *Definite Management,* as contrasted with casual methods of control and organization:—(1) exact and clearly stated limitations of line authority, preventing the conflict of orders, loss of energy wasted in the efforts of one executive to encroach upon the preserves of another executive, and the various other inefficiencies of the feudal type of organization; (2) functional foremanship, which combines staff specialization with line executive powers in the same individual or in different individuals with such concert of action that the effect is equally effective.

8. *Intensive Labor Development.*—(1) labor turnover reduction; (2) organized employment; (3) safety first; (4) health insurance, hospitals, etc.; (5) welfare work; (6) profit sharing.

9. *Analytical Time Study.*—The scientific determinations of exactly how much work should be turned out by each employee.

10. *The Bonus Reward,* involving the payment of each worker—laborer, foreman, superintendent, salesman or manager—in exact proportions to what he accomplishes for the company.

11. *Written Instructions and Standards.*—The preservation in permanent form of all facts leading up to decisions and of all decisions, either staff or line, reached by the executives and the experts of the company.

12. *Modern Business Ideals.*—Implying that supreme common sense, which has a regard for the highest business ethics, believes in the fair deal toward labor, competitors and customers, possesses a willingness to exchange ideas with others and an open mind toward new ideas and toward technical and expert counsel, and is willing to participate in personally, and to support progressive movements of real merit, and which practices to the best of its ability what has been characterized as "The Golden Rule in Business."

The names you call things do not matter. The important thing is not to foist a lot of unnecessary paraphernalia upon a poor trusting manufacturer who has become so enthused by the literature on modern industrial management as to expose his whole plant to your tender mercies without reserve. Analyze the particular situation and give him exactly what his particular case needs—no more, no less. Make the big savings first, so he can realize on them as soon as possible. Leave the refinements until the end. Don't give way to the professional pride in technique of the practitioner who prefers a "successful operation" to the patient's recovery.

To illustrate what I mean, recently in a large plant on miscellaneous and repeat work we increased the output over 40 per cent, cut the principal supply—coal—20 per cent, increased the man-tons over 20 per cent and the labor turnover 50 per cent in less than a year, without using a stop-watch or paying a single man a bonus. That is coming later, but the preliminary analysis disclosed the necessity for standardization, more complete records, and the ratchet principle. In a similar plant about two years previously the preliminary analysis led to the belief that a "blanket bonus" for increased output, if paid to certain foremen, would have beneficial results. In that case the process was, in a way, completely reversed, and events justified the course taken. Ritualism would have been aghast a both courses.

The chapter on the psychology of management seems to me unique. In fact, I am inclined to go a step further and to carry the theories on through to the higher executives of the company. Certainly the ancient belief that to the philosopher all things were possible is in a measure borne out by the statement of James which is quoted. At least, observation has taught most industrial engineers who have survived as such, that a thorough knowledge of psychology—a knowledge of human nature and ability to apply such knowledge through what is usually known as "personality"—is an absolute essential.

I am in hopes that Naval Constructor Roberts' monograph will be given the widest publicity. Scientific industrial efficiency is in the air. France is studying it. England looks to it to solve not only her industrial but her financial problems after the war. America must follow suit, and I know of no better way to help us to meet the economic struggle which is surely coming than by the widest circulation of such non-partisan papers as this through the immensely effective organizations which our country has ready to hand in the staffs of Secretary Redfield, of Secretary Wilson, and of the various boards which have been formed to organize American industry for victory.

Naval Constructor Roberts:—Mr. Gantt has furnished us with a written communication on this subject, and I think it may be properly included in our proceedings.

Mr. H. L. Gantt (Communicated):—Without having been able to devote the time necessary to studying your article thoroughly, I have gone over it with sufficient care to assure myself of its contents, which I note are concerned mainly with the problem of handling labor.

One sentence on page 257 seems to give a key to the subject as you understand it. This

sentence:—"In hiring, it is the duty of the industrial manager to take any class of human material and discover what it can do best," I would modify to read, "and discover what it can be trained to do best."

The labor problem, however, is not the leading problem to-day. We have proved in so many cases that under a proper system of management the labor problem tends to solve itself, that I am no longer concerned much with the labor problem, but am devoting all of my efforts to the managerial problem. Unless managers and business men recognize their responsibility to the community at large, they can hardly expect the workmen to recognize any responsibility to them. We continually hear criticism of workmen who watch the clock and are concerned only with the wages they get. This will continue just as long as manufacturers and business men concern themselves principally with profits and only secondarily with what they deliver for those profits.

The seriousness of our national situation in the war in which we are engaged does not seem to be realized by either the employer or employee to a large extent, but it is absolutely true that we shall be unable to win in this war unless we can make service first and profit second. We justly complain of strikes by workmen to promote their own interests, which hold up the production of ships. As long, however, as business men are still setting the example of private interests before public service, we can hardly expect anything different from the workmen.

This principle has been recognized by many people throughout the country, and the attempt at governmental price-fixing is a proof that our business system as now constituted is unable to solve its own problems. All recognize that governmental price fixing is only a makeshift and cannot endure for any great length of time. It certainly is not a permanent solution. It is frankly an attempt to make the business system serve the community during the emergency of the war. Why not put all our efforts towards making business men realize that they themselves can accomplish this object far more successfully than can the general government, if they will only accept the principle that not only in war time but in peace time the slogan of business should be, "Public Service First, Private Gain Second"?

You will pardon me for going so far away from the subject about which you have written, but if our general policy is wrong, the details of the methods by which it is carried out are of but little importance. On the other hand, if our general policy is correct, correct detail methods will soon be developed.

Mr. E. L. Hurd (Communicated):—I am not qualified to enter into a discussion of Captain Roberts' paper, but it does seem to me to be along the right lines. Taylor and the other pioneers opened up a new country, which naturally was over-exploited by their enthusiastic followers, very many of whom entirely overlooked the human element.

I think one of the problems of all industrial concerns of to-day is to have enough system to know where they are, and not to waste profits through over-system. In order to bring about this compromise between the old and the new, the efficiency man, so-called, must be followed up by some hard-headed, old-fashioned practitioner, who will knock away the non-essentials. You make no mistake when you continually call attention to the fact that each business is different, and that what is good for one is not of necessity good for another.

Mr. Dexter S. Kimball (Communicated):—I have read the paper by Naval Constructor Roberts entitled, "An Analysis of the Principles of Industrial Management," with

great interest and consider it a very timely contribution to this much debated subject. As the author states, the plans and proposals of Mr. Taylor and others who have endeavored to introduce innovations into methods of management and the acrimonious debates which these proposals so often occasioned can now be seen somewhat in perspective through the great cloud of conflicting literature attendant upon these discussions. The time has come, perhaps, when we can evaluate them calmly and intelligently with a view of determining what useful methods of all those that have been proposed will remain with us.

Every manager of a modern industrial plant of any appreciable size must form for himself some philosophy of management. He cannot, in general, build up a successful plan of management from his own experience. He must draw, and draw largely, from the experience of others. This paper presents in a concise manner the most important features of management that have been presented in recent times. If it does nothing more than to call the manager's attention to the many components that he *may* incorporate into his philosophy of management, it will be well worth while.

As the author has stated, there is little that is new in these modern proposals. Most of them rest upon simple and well-proven economic principles, such as division of labor. And careful consideration has made it clear that scientific management, so-called, rests on a sound economic basis. It most surely will increase production if applied under the proper conditions. On the other hand, it has become equally clear that these new methods are purely labor-saving devices that affect the labor problem in exactly the same manner as labor-saving machinery. They do help us to create more wealth and in the long run all will be benefited. The author has shown statistically that this is true in the section on political economy in management. At the same time it is now clearly recognized that these methods are esentially aids to production only, and that they do not in any way change the old laws of supply and demand and other economic laws that affect the distribution of the fruits of industry. They are productive principles only, and involve no new distributive principles.

The author has not, however, sufficiently emphasized the great basic reason for the workers' opposition to these new methods, or, for that matter, to all new methods. The worker may fear over-production, as the author states, but he fears much more the effect of labor-saving methods upon his personal status in the industrial field. He knows instinctively that such methods portend change in industrial methods, and that these changes may eliminate his trade or, at least, leave him only a fragment of it. The idea so frequently held out that the better class of workers are benefited by being transformed into planning officials, while plausible, is not possible of realization in practice for all skilled men, and in the long run any industry that is greatly transformed by labor-saving methods will be found to be equipped, after a time, with a different class of men than those that originally practiced the calling by handicraft methods. There is little or no resemblance between the working force of a modern shoe factory, which the author uses as an illustration, and the old village shoemaker. The industry is dependent, even, on a different class of men for providing the tools on which shoes are made. Change and momentous change is involved in the introduction of all of these modern labor-saving methods as in the introduction of labor-saving machinery. The worker may not quite understand what the change may be, but he fears it all the more for that reason.

The writer is not arguing that these new methods should not be adopted. Such an argument would be a plea against progress, and the human race never puts behind it any

ways or means for improving economic conditions. And apparently no such progress can be made without suffering on the part of some portion of the industrial community. But we shall undoubtedly be much more careful in introducing labor-saving methods in the future than we have in the past, and we shall endeavor, no doubt to minimize the amount of suffering that almost invariably comes from radical changes of this sort. The modern humane point of view demands that this be done.

On the other hand, we must make further progress than we have made if we are to reach a point where compulsory poverty will be no more, and where all men can have at least a fair share of physical comfort and spiritual well-being. The way apparently is through the methods that the author has summarized, or through similar methods. They should engage the careful attention of every manager, for the general principles that they propound are here to stay. The degree to which they will be applied will rest with experience to decide. Shipbuilding will be no exception. The writer had the fortunate experience of spending a number of years in the shipbuilding industry in his younger days. Much progress has been made in the industry since then. Yet he would venture the opinion that the industry as a whole has not made as much progress along the lines of modern management as have some other lines. I would again repeat, therefore, that I consider this paper a very timely contribution.

Mr. Henry G. Smith, *Member* (Communicated):—The Society is fortunate in having presented to it by Naval Constructor Roberts this elaborate paper on the subject of "Industrial Management." This Society is indebted to Mr. Roberts for the painstaking care and labor performed by him in preparing this paper and will find it a valuable addition to its records.

Mr. Roberts has presented this paper, to some extent, from the point of view of the shipbuilder, but he has not apparently brought out all of the points that guided the shipbuilder in the adoption of certain of the principles of "industrial management," while neglecting to adopt others.

It is pleasing to note that the author has abandoned the expression "scientific management" in favor of the more suitable term "industrial management," as the former expression has become hackneyed of late years to an extent liable to discredit it, and it can be assumed that the management of most of our large industrial concerns, at the present day, is in the hands of men sufficiently enlightened to be classed as scientific so far as the term applies to management.

The subject of "industrial management" from a scientific standpoint has been one that has engaged the attention of managers probably ever since industry began, and before the extensive experiments carried on by Taylor, Emerson and others were dreamed of, but these men have undoubtedly brought to the front and stimulated certain phases of industrial management with unquestionable beneficial results, but one fails to find in more than a very few isolated industries the adoption of the Taylor system as a whole, and the question is therefore natural—Why is this so?

An axiom of all industrial managers is maximum output, with a corresponding adequate return to the employee and a high grade product. The maximum output and the quality of the product both depend upon several factors, one of which is machinery, tools and other inanimate objects, subject to the direct will of man, and which can be controlled when certain principles have once been established; the other, a more important element, is the work-

ing man, where human nature comes into play and which is controllable just in so far as he is convinced that he is receiving fair play and that the basis upon which he is working is one tending to his betterment as well as to that of the employer. It is my belief that it is this factor that was discounted by Taylor in his earlier experiments and that has led to a less complete installation of his system in various plants. You can not deal with the working man as a piece of machinery, or as a commodity, and any plan in which he is involved in management must be cooperative. He must be convinced that the basis upon which he is working is to his advantage, or at least that it is not to his injury, and any system that is not built upon this basis will fail.

It is my belief that if the Taylor system had dealt with an average and not with the best man that it would have met with greater success, and it is the human element confronting each industrial manager which makes him pause in the adoption of any "scientific system."

The experiments with machine tools, cutting speeds, feeds, etc., the experiments with belting and with other methods of driving machinery are invaluable and have led to the establishment of fixed rules which, if followed, can not but give handsome results. Even here, however, the adoption of the Taylor principles can not be made without reservation, for the reason that the human element again comes to the front in the operation of the machinery built to a rule, and just in so far as the operation of machinery can be carried out according to fixed rules just so far are the expenditures made for the improvement of this machinery of value. The carrying out of any elaborate system involves complication, as it results in adding men to the organization, each one of whom must be depended upon to act in accordance with the prescribed rule to produce results, and if this man fails to follow the rule you do not get the results. This, therefore, brings to the front another reason why the Taylor system in its entirety might be a failure and suggests to the manager that simplicity in system is necessary for results.

There is undoubtedly much of good that can be abstracted from the experiments of Taylor, Emerson and others and applied to any industry, but, in the opinion of the writer, their adoption as a whole would be totally impossible in any branch of the shipbuilding industry, and that the Taylor system as a whole is too elaborate to install in its entirety in any industry unless it be one of absolute duplication of product.

The analysis to produce results looks simple, but is extremely difficult. You go from the manager through various steps to the employee, and you look to the employee for the proper amount of a good product, and the only question is—How can the right kind of product be obtained in suitable quantity with proper remuneration to the employee? An attempt to solve this question has led from day work through piece work, premium work, bonus work and all possible methods for obtaining the result in the best way, but the real question is how to obtain the closest cooperation between the employee and the employer and to place upon the former the part of the responsibility for the product which should be his share, and to get him to accept the responsibility and to give a suitable return to the employer. On the part of the employer it is his business to see that the remuneration to the employee and his welfare are looked out for to a degree that will hold that cooperation. The methods of accomplishing these results are varied, and no final solution has been found, even in the best managed industries. "Fair play" is the first step involving confidence on the part of the employee and a willingness to abide by any agreement he has made, whether written

or verbal, and a similar confidence on the part of the employer that he can depend upon any agreement made with him by his employees.

In a shipyard the work is so varied that different methods of paying the employee for output are adopted. I have always been of the opinion that the premium system was one of the steps to piecework and was only permissible where standard piecework schedules could not be adopted, and that the greatest satisfaction to an employee is a fixed standard of prices which cannot be changed without mutual understanding.

It is probable that the greatest satisfaction, however, comes to any man, whether manager or employee, in the payment of a lump sum bonus at stated periods for results produced, and, while it may be small in amount, if added to a daily wage, its appearance as a substantial sum in ready cash at stated periods creates a great feeling of satisfaction, and if it were possible to extend the bonus system to each employee by some direct measure of his work, I believe it would be productive of the best results. This, of course, closely approaches the profit-sharing scheme.

Mr. Henry R. Towne (Communicated) :—I duly received an invitation to discuss this paper, but only a few days ago received the paper on industrial management. The remaining time is so short and the other demands on me at present so urgent as to preclude my complying with your request for a discussion of your paper to be included in the final record. I have looked through it with sufficient care, however, to be much impressed by its comprehensive and intelligent review of the origin and development of the new science of industrial management. It is the best brief review of this subject which has come to my notice, and I hope may ultimately be published in separate form and thus become available to all who are interested in this most important subject. Its clear and concise statements of the various theories which have been advanced, the arguments for each, and the results of experience in this field, make the paper not only interesting but very helpful to any student in this field.

I will comment on a few points to which the paper refers:

Page 173. The experience you refer to at Bethlehem was duplicated in our works at Stamford. My early friendship with Mr. F. W. Taylor had caused him to give personal attention to our case after we had decided to install the Taylor system in one of our large departments. He put Mr. Barth in direct charge, but also kept in close touch with the work himself. After nearly three years of preparation, and the system not yet completely organized, I notified Mr. Taylor that we proposed to take it into our own hands to complete, and stated frankly also that we regarded it as overloaded with detail by Mr. Barth and proposed to simplify it. Both of them protested and stated that by so doing we would destroy all of their previous work and reduce the plan to practical failure. It is a pleasant evidence of Mr. Taylor's broad-mindedness that within two years, and after visiting Stamford and looking over what we had done, he acknowledged to me that for our purposes the changes we had made were justified and that his previous critcisms were withdrawn. Since then we have gradually extended the system to all of our departments.

Page 193. Your statement here concerning my "gain-sharing" plan is not quite correct. At that time in New England the "contract system" was in general use under which a superintendent or foreman, as "contractor," agreed to furnish certain parts or completed articles at a unit price, the company charging him with all labor, supplies, etc. My "gain-sharing" plan provided for a distribution between the contractor, his employees and the com-

pany, of all saving effected by increased efficiency and by increased economy in the use of appliances and supplies. It did not give the employees a share "in the general profits of the firm." On the contrary, as stated in my paper on "Gain-Sharing," in Vol. 10, 1889, A. S. M. E., my purpose was to include in the account all items concerning which the employees could influence the result, and to exclude all items which were not subject to their control or influence. My previous paper, "The Engineer as an Economist" (Vol. 7, 1886), has been referred to as embodying the first published plea for the creation of the science of management.

On page 239 is discussed cost accounting, which I regard as one of the most important divisions of the subject. In this connection, I invite attention to my short paper, "Axioms Concerning Manufacturing Cost," which appeared in Vol. 34, 1912, A. S. M. E.

On page 251, I am glad to note, reference to the benefits from the embellishment of yards and buildings in industrial plants. In our works at Stamford we have two large green-houses and maintain flower beds and shrubbery wherever practicable throughout the yards.

Mr. Harrington Emerson (Communicated) :—Mr. T. G. Roberts' very valuable analysis of the Principles of Industrial Management reached me at St. Louis, November 15, too late, therefore, to prepare in time for the meeting the courteously requested written discussion.

The following is in part what I would have written and sent in had I been in time. What am I to criticise?

1. The general principles of industrial management?
2. The Taylor system of industrial management which Mr. Roberts seems to accept as final?
3. The able author's own point of view?
4. The kindly references to my own teachings and practices?

Perhaps a few words under each of these headings will by implication contain all of both the approving and questioning criticism I wish to make.

1. *The General Principles of Industrial Management*:—Mr. Charles Darwin, in his epoch-making work which appeared in 1859, called attention to the workings of natural selection in bringing about modifications of living organisms, but Mr. Herbert Spencer showed that the laws of evolution were universal and eternal in scope, applying equally to the star galaxies, to solor systems, to the earth, to everything on the earth. As he expressed it, evolution consisted in change from the undifferentiated heterogeneous to the differentiated and organized.

Similarly, management and organization may be considered from the circumscribed and differentiated point of view of the shop or industry, or they may be recognized as coeval with creation. If we take the latter view, as I do, we recognize that any so-called principle of industrial management is only an uncovering or recognition of what always existed, that in so far as it is an innovation, it is only of permanent value if it adheres to the eternities.

Personally, I study shop and industrial systems, organization and management, by correlating them with the fundamentals of organization, which fundamentals I find evidenced plainly in every plant or animal that ever lived. When there is one type and fundamentally only one of individual organization manifest in every one of the millions of animal species

and billions of individuals during a period of millions of years, I question the ability and the probability of any one improving on the type. When I find a tree seed, dropped on a mountain slope, able, without members of either locomotion or prehension, to evolve and survive through three thousand years, converting the inorganic into the organic, I learn from that tree what the fundamentals are that must govern if a humanly developed system of management is to endure. Instead, therefore, of generalizing from the Taylor system upwards and outwards, I would like to analyze and dissect that system from the outside universal and eternal point of view. Such a discussion now would lead too far.

2. *The Taylor System of Industrial Management:*—For Mr. F. W. Taylor I have the greatest respect and admiration. I knew him and his work well for fifteen years. He always reminded me of a thoroughbred stallion turned loose on the range amongst scrubs, therefore destined to leave his imprint on generations to come.

Mr. Taylor came of excellent lineage. This important qualification was supplemented by a world training in foreign schools, especially French, so that he had initially the wider point of view. By entering the shop he brought this unusual personality, both of heredity and experience, into direct contact with things as they are, and "ought not to be." He was observing, logical, persistent, creative, and inflexible. With him the "fittest" method in operation or quality had to be made to survive. Older than Mr. Taylor, I had recognized and applied principles of organization at a period when Mr. Taylor was still under age. I had evolved special application of these principles to shops and achieved shop success before I met Mr. Taylor in 1900. I found much, very much in his work to admire, to adopt, but also some details to reject. I have constantly directed the work of about forty assistants, the residual cream of several hundreds, and our work has been applied more or less in over 300 organizations, and in this work we have freely used not only the vast accumulations from our own experiences, but also the much we found worth while in the teachings of Mr. Taylor and his disciples. We also found much worth while in other recognitions of universal laws. For instance, long before Mr. Taylor or I were born, the race-horse man had recognized the immense value for horses of heredity, environment, training, education, experience, health, reliability, industry, spirit, temperament, aptitude. Race-horse men first used the stop-watch for most minute studies. For the sake of saving fractions of seconds, they studied and bettered every part of the apparatus and equipment from track to sulky, from harness to toeweights. The first photographic motion studies were made by Muybridge, and they were of the trotting horse. In a different field Luther Burbank's work of selection of the best is also fundamental and of wide-reaching practical importance.

Illustrations of the scientific investigating and bettering spirit of the age working in all departments of human interest, exemplified by Mr. Taylor as to industrial shop problems, could be multiplied.

But even in the domain of shop management I may dissent as to details. I read with great profit Mr. Taylor's studies of belting, and then we applied our own more effective methods. We rejected wholly his belt tension instrument and substituted for it the finger touch for tension determination and the insert for adjusting lengths. A belt, even if scientifically measured as to length for tension, will stretch loose in an hour—will vary in tension with changes in weather. The light finger tap and the correction by shorter (or longer) insert was found practical. We also adopted the angle release slip as superior to any other method for the determination of allowable load. Our experiences were on a very large scale over a long period of time, and, at insignificant expense, showed that unsurpassed re-

sults, both from the point of view of belt failures and belt maintenance costs, were attainable and attained. Mr. Taylor's and Mr. Barth's work as to belting gave us the stimulating start; it was excellent, but not final, either as to methods or results. Knowing their work, having derived great profit from their teachings, I nevertheless felt at liberty to improve.

Mr. Roberts' Own Point of View:—His very able and valuable paper answers this question. It seems to me too particular, to give too much insistence to what I believe to be only minor, even evanescent, phases of Mr. Taylor's great work and influence. I can disagree with Mr. Taylor as to the best method of establishing belt tension, and I can also reject the theory of functional foremanship without lessening my regard for his, as it seems to me, far greater merit of pointing out, of insisting, of demonstrating that some practices are almost unbelievably better than others, and in resolutely and inflexibly investigating the exceptionally good until it is mastered and made the norm. Is not this the final hope of all civilization?

4. *The Reference to My Own Teaching:*—Books I wrote ten or even five years ago do not fully either present to-day's convictions or practices. The whole world has been modifying its opinions since August, 1914. I also claim the right to grow and to develop, to embody in my present beliefs the teachings and lessons of an exceptionally wide practical experience. The author is kindly complimentary to mention my opinions at all, but he considers specific details rather than the underlying fundamentals.

Let us consider, for instance, line and staff versus functional foremanship. They are not comparable. Line and staff is universal, functional foremanship is a special application.

There is only one limitation preventing an able man from becoming infinite in power and knowledge. He does not live long enough. Fifty, sixty, seventy, eighty years is not enough. What would he do if life were ten times as long? But line may give him unlimited power, and staff may give him unlimited knowledge.

The essence of line is that the head of the line shall know more than the man under him. The addition of subordinates, similar, albeit weaker and inferior units, extend his power. Instead of fighting with his own fists, he may direct ten million men. Even if each has only one-thousandth part of his individual power, the aggregate is ten thousand times as strong.

The essence of staff is that each member of the staff shall know far more about some particular thing than the head of the line he is serving. Therefore, the staff man, by his special knowledge, supplements without limit the constricted knowledge of the chief. The staff man is not a subordinated inferior unit; he is a correlated superior unit.

The individual is but a point; line help makes him the apex of a spinning cone; staff supplement converts him into a spinning cylinder of greater diameter than the cone.

This conception of line and staff can not be analyzed into four or five functions correlated to functional foremanship. Staff value is as universal as food values, as wide as education. Each line head takes what he needs or can utilize.

Functional foremanship may be a special and valuable blend and application of line and staff, but line and staff can no more be squeezed into the limitation of functional foremanship than all life can be squeezed into the limitations of a specific individual.

The general principles of organization and of management were neither discovered nor are they finally applied in this age. We are, however, beginning to open our eyes to the lessons of infinite past experience and demonstration, and also to the infinite probabilities of the future.

Naval Constructor T. G. Roberts, *Member*:—I agree with Mr. Gantt that the peace time refinements, such as time study, motion study, and other measures for reducing costs, are eclipsed by war time conditions. To accomplish a certain work, there are two ways which are extremes, one by the most economical route, where time is a secondary consideration, the other by the most expeditious route, where expense is of secondary importance. As in the case of a battleship, the economical speed is not the full speed ahead, and the full speed ahead is what is demanded in war. At the same time, speaking largely, there are many elements of management where labor saving and maximum expedition go hand in hand, and it is necessary for the war time manager to mould the economics of war time work, so as to give maximum consideration to speed and secondary consideration to cost. In building the Canadian submarines for the British Government at the early stages of the war, it was reported that the amount of labor employed was proportionately so great that the men were constantly in each other's way, and the waste of labor through lost motion was the direct opposite of the saving in this particular demanded under economical management. The expedition with which the vessels were completed was so great as to be remarkable.

I will have to amend my remarks about motion study, as I did not realize it had been carried to the extent that Major Gilbreth's cyclographic pictures show. As he is a pioneer of motion study, I am sure that the developments shown in his discussion will be interesting and informing in all particulars. Mrs. Gilbreth, I understand, is his collaborator in motion study, as well as in the publication of a leading work upon the Psychology of Management, and it is regretted he has not dealt more largely with that phase of the subject. As to scientific management being a science instead of an art, there need be no great difference of opinion about that, as the accepted definition of an art is science put to practice, and it is believed that the word art better expresses the idea.

Replying to Mr. Emerson, it is necessary to read my paper carefully in order to see that I have not accepted the Taylor system largely as final, but have endeavored to evaluate its constituent parts, each for what it is worth.

As to my point of view being too particular as respects Mr. Taylor's work, I consent that it is so, to the same extent as the results throughout modern industry which have flowed therefrom, and to the same extent that Mr. Emerson's own work is predicated thereon.

I agree with Mr. Emerson that line and staff and functional foremanship are no more comparable than your hat compares with your vest. The Emerson system contains men who are performing the same work as Mr. Taylor's functional foremen, whether so named or not; and "line and staff," being a theory plus an efficiency engineer, is as much present in the Taylor system as in any other. It is only a question of verbiage. As to the developments and variations from the Barth and Taylor belt analyses, the evolution which Mr. Emerson has undertaken has likewise occurred in the Taylor system, where the touch of the hand has been largely substituted for the mechanical instruments, which was a very natural event, just as a person sheds his first teeth at a certain age.

Major Gilbreth's cyclographic golf pictures have been rectified in the final printing, the two exhibited being sufficient.

Before closing, I wish to clear up an inference which may be gathered from my remarks on the subject of welfare work. Mr. Wakeman's paper No. 1 of this meeting, on the Service Department of his shipyard, was written, I understand, at the last moment after my paper had been circulated, and is suitable as a corollary thereto, as well as an

elaboration thereof, in respect of shipyard application. In my discussion of his paper and the counter-discussion of one of my colleagues, the question was raised as to the availability of welfare work when applied to the lower grades of foreign workmen, such as at some of our metropolitan shipyards or navy yards. There are two extremes in this question also, of which the latter is one, and the value of welfare work varies in proportion. The other extreme, where the conditions set forth in my paper are more suitable and more necessary, occurs in the case of a large industry located at a distance from a large city, where the employees are wholly dependent for amusement and social life upon the locality where the works are situated. In this case, the maximum of welfare work is indispensable for the health and contentment of the employees in order to hold them at the place. The United Shoe Machinery Company's works at Beverly, Mass., is an example approximating such an extreme. The other extreme occurs in the case of the foreign Slovaks and other workers located in a great metropolis like New York City. They can hardly appreciate such provisions of management, being farthest removed among those who are capable of being educated up to it, and their scattered homes and other diversions available in a metropolis are greater forces of attraction than any welfare work can counteract. It is here that occurs the minimum available application of this principle. In a case like the Fore River Shipbuilding Company, located not immediately in a great city nor far removed therefrom, the average condition occurs where welfare work is taken part in and appreciated by some, but not by a great many others. In this, as well as in other elements of management, the actual conditions obtaining at any particular plant must be weighed and the principle applied with discretion, in accordance with its availability, and in which no fixed formula can be laid down or attempted for all industrial establishments alike.

The Chairman:—On behalf of the Society, I thank Captain Roberts for his most interesting paper, and also these experts in industrial management for their kindness in coming here and adding their comments to the paper.

Before we take up the next paper, I wish to remind you again of the banquet to-night, and to suggest that those who have not obtained tickets and arranged about their sittings will go up to the seventh floor, to the office of the Society, where they will find Mr. Kain, the assistant secretary, who will be glad to arrange for their tickets and seats.

Referring to the banquet, I may say that Mr. Taylor, our president, told me this morning the expectation is there will be about six hundred present to-night, so it is expected to be a very great affair. I think that will be the largest attendance we have ever had at one of our banquets.

The attendance at this session is much larger than at any of the others we have had this time, and I want to call your attention to a little thing that was done yesterday, so that you may know about it and have it in mind as a guide, or not, as you please.

It is quite evident by looking around you that there are a number of our friends in uniform, and there are going to be a great many more of these friends in uniform at the banquet to-night. You know what a beneficent Congress has done in looking after the welfare of our soldiers and sailors, in the way of sumptuary legislation, in a way that we never believed possible in this country; but it is nevertheless true that there are certain restrictions placed on the freedom of action of these gentlemen. It was suggested yesterday by some of the civilian members that, out of courtesy to our members in uniform, it would be a very tactful and proper thing if all of us in civilian clothes acted voluntarily the same

way that our members in uniform have to act involuntarily, and it was put to a vote yesterday simply to get the sense of the meeting. Of course, the Society cannot pass a vote, directing that the thing shall or shall not be done, but it was found to be the sense of the meeting that all of the members should make the banquet what is known as "A dry banquet." Now if you care to have it done this afternoon, I would be glad to put that question again, and ask whether it is the sense of the meeting now, with this large number of our members present, that we shall have a dry banquet out of compliment to our members in uniform, who are not allowed to partake of any alcoholic refreshments. Is that the sentiment of the meeting? All in favor say "Aye;" opposed, "No." There are no noes, and it is unanimous. This is not obligatory upon anybody, but it merely enables you all to express an opinion, and I am very glad, indeed, to have it done. I think it is a delightful little courtesy, and something that our members in uniform will surely appreciate.

The next and last paper on the program is No. 15, entitled "Gyro Ship Stabilizers in Service," by our good friend, Mr. Elmer A. Sperry, Member.

Mr. Sperry presented the paper.

GYRO SHIP STABILIZERS IN SERVICE.

By Elmer A. Sperry, Esq., Member.

[Read at the twenty-fifth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1917.]

The encouraging results of the last two years prompt me to submit for record in our annals, somewhat in pictorial form, the marked progress made in the adaptation of the gyro stabilizer to all sizes and types of vessels,—commercial, pleasure, and naval.

Experience under the severest service conditions has convinced all who have been brought into intimate contact with the performance of the stabilizer, that there now is no further reason why ships should roll. Nor is this confined to any particular class of ships. All ships that are a product of modern naval architecture, with their moderate metacentric height, come under this head. As a matter of fact, a "tender" ship may be said to roll simply because it has nothing else to do, and it requires only a small counter force for complete suppression of the roll.

All rolling of ships is the result of an accumulation of successive wave increments, and it has now been thoroughly established that a stabilizer need be only large enough to counteract each of these increments. One unexpected result of our experience has been that the alertness on the part of the stabilizer quickly to catch and suppress each increment while in process of development is of greater importance than its size or stabilizing power

The stabilizing equipment itself, considered in the light of the wonderful results that it accomplishes, is insignificant in points of both size and weight. It consists of a rugged and comparatively simple mechanism; even for large ships usually weighing not far from one per cent of the displacement. The cost per pound is not far from that of other mechanical equipment on shipboard, and with increased standardization the cost will naturally be lessened.

The action of the stabilizer in preventing a ship from rolling in a heavy sea is a never failing source of interest. The ship, while itself free from rolling, seems to become simply a conductor, or medium of transmission of static stresses between two vigorously active elements,—the sea on the one hand, and the gyro precession upon the other,—and it is obvious to the most casual observer that the two are keeping pace with each other and working coordinately—technically in exact opposition to each other. As the activity of the sea increases, the precessional activity of the gyro is seen to increase proportionately; and as the sea dies down, so these precessional activities grow less and less accordingly, while the ship simply stands by and refuses to partake of the motion of either.

The many and far reaching advantages of a stabilized ship, are by no means appreciated, and this is quite natural, considering the entire absence heretofore of

any practical and simple method for the effective suppression of roll. These advantages extend considerably beyond the obvious. The increase in physical comfort of every one on board, to say nothing of the greater security and ease in preparing and partaking of food, is extremely apparent. Also, in naval vessels it is apparent that a level gun platform is of the greatest advantage in making hits, which is the ultimate object of any navy. It is further clear that the enormous depreciation suffered in the transportation of live stock in rough weather can be eliminated. But what may not be apparent without investigation is that the tremendous stresses set up in the ship's structure due to rolling are practically eliminated.

I am often asked if the ship doesn't sustain greater strains when being stabilized. My answer is that a ship is not a dock. It does not have to abut or withstand the impact of the waves. Instead it rides the waves with wonderful ease. I venture to state that no one can go through the experiences on a vessel that can be alternately fully stabilized or permitted to roll at will, without being emphatically impressed with the wonderful ease of the ship's progress during stabilization, and the entire absence of buffeting or wave impact, which is so painfully apparent when the ship is laboring heavily. The sensation when at sea on a stabilized vessel is unique. The ship gently rises and falls as the major wave disturbances pass under her. The change between the two conditions seems incredible. The decks, which, while the vessel was rolling, became at times deluged with seas, invariably remain dry during stabilization. There is no impact of the waves, not even spray coming aboard, and there is an entire absence of duress, strain, and creaking, present when the same vessel is allowed to build up until rolling heavily.

Another element among those not so apparent relates to the propulsion of the ship. Strange as it may seem, a ship that is free from rolling is not retarded by the seas. It has now been definitely ascertained that such a ship on a measured mile with a given number of revolutions of the screw maintains a speed in heavy seas which is practically identical with that accomplished in calm weather. This constitutes an advantage of immense importance, which alone would probably save in fuel and stress upon propelling machinery many times the cost of the stabilizing plant. This not only coordinates, but serves as additional proof to the proposition that a stabilized vessel is substantially freed from sea impingement, duress, and stress generally.

Another important point, which was unexpected, is that a stabilized ship holds her course remarkably. A ship when rolling heavily has a sinuous course and requires a very great amount of helm. No less an authority than Admiral Taylor recently stated that even small helm angles are responsible for retardation of a ship to an extent very little appreciated. The rudder constantly alternates from right to left. Under identical conditions of both sea and heading, the same ship when stabilized is found to revert to conditions obtaining in practically calm weather, almost no helm being required. The master of one stabilized ship told us that his ship when stabilized practically steered itself, requiring almost no helm.

From a technical standpoint, this phenomenon of the helm obeying fair weather conditions in heavy seas, simply because the ship itself is stabilized and free from

rolling, introduces a new field of investigation, and one that is full of significance as well as interest. Other of these unsuspected results of stabilization of ships will also be found full of significance, and their investigation will doubtless throw light on phenomena now only partially understood.

Advantage has been taken of the lull in yachting, caused by the requisitioning of all boats of any size by the Government, to gather some of the data we have accumulated from the performances of stabilizers under service conditions, which are submitted herewith.

Fig. 1, Plate 50, shows a number of yacht equipments suitable for boats ranging from 140 to 550 tons displacement.

The small Widgeon equipment, similar to the stabilizer shown in the extreme right of cut, has been giving excellent results for the last two years, no overhauling being necessary. This speaks well for the ruggedness and reliability of the equipment, which has often been called upon to hold the Widgeon on an even keel, the ship having seen considerable service.

The stabilizer on Mr. H. P. Whitney's yacht, Whileaway, has now been in operation for a year or more, and as this equipment is typical of the standard yacht stabilizer, its various units and the function of each will be explained.

Fig. 2, Plate 50, shows the gyro unit of the equipment for this 460-ton boat. The gyro proper runs as a self-contained unit, the oil flow which cools and lubricates the bearings being maintained by a small gear pump directly connected to the rotor shaft, the oil passing up through strainers and coolers to the bearings. By the use of a special impregnating material perfected in connection with our gyro compass and used upon thousands of compass casings, we are enabled to maintain a partial vacuum of from 15 to 20 inches within the case with the small vacuum control unit shown in Fig. 5, Plate 51. This saves many horse-power which would otherwise be dissipated in air wash within the casing.

The problem of windage has proved to be a very interesting one. In these large spinning wheels, presenting smooth surfaces where they can be spun both with and without casings, a most unique opportunity is afforded for studying the exact laws governing windage and also the proper clearances between wheels and casings, to obtain the maximum power saving. So, considerable time and expense have been devoted to this study, with results that are now found to be perfectly coordinate and very exact.

In the course of this investigation, some interesting phenomena appear. Each wheel is subjected to a super-stress test, and although the rim is highly polished, the blower action when not encased is very much more energetic than one would suppose. For instance, it is found almost impossible to penetrate the layer of air near the wheel with a pencil point. Our engineers have also found that they could lean against this air layer vigorously as though it were a solid cushion, without the slightest danger of coming in contact with the wheel itself.

Fig. 3, Plate 51, shows a wheel similar in design to that on the Whileaway, but somewhat larger for a 550-ton yacht. A perfect running balance is obtained by

slightly changing the weights of the equally spaced plugs, which are clearly seen in the photo, and in fact these wheels are so perfectly balanced at high speeds that the sensitive Frahm vibrating meter fails utterly to respond and cannot pick up and indicate the speed of the wheel. The small A. C. driving motor is shown on the shaft, together with the specially developed roller bearing, which has operated excellently at very low frictional coefficients under service conditions.

Fig. 6, Plate 51, shows the precession unit for the Whileaway stabilizer. The electrical brake "B" is released simultaneously with the starting of the precession motor "A" and the pinion "D" working through the worm and wheel "C" and engaging with the large precession rack, precesses the main gyro as directed by the control gyro, Fig. 4, Plate 51, the exact amount required to neutralize each wave increment as it starts to impinge the ship.

Among the many interesting performances of this simple little mechanism constituting the control gyro is its automatic action in limiting the precessional velocity of the gyro. This is illustrated when a particularly large wave is encountered, which would tend to roll the ship through a wide angle. The gyro, were it left to itself, would tend to increase the angular velocity of its precession unduly, in its effort to quench this abnormal wave increment, thus tending to drive the precessional motor "A." The counter electro-motive force thereby developed heads off the main current supply and allows the brake to operate directly though in greatly magnified proportion, thus automatically holding the precessional velocity to the normal, even under extreme conditions.

Another interesting phase of this small control gyro is its perfect control over the centralization of the unit. Thus the precession arcs are continually centralized, even when the sea conditions are such as would cause a much greater roll of the ship to one side of the vertical than to the other.

The switchboard for the standard yacht equipments is shown in Fig. 8, Plate 52. By means of the circular switch (lower left), the equipment may be instantly changed at will from a stabilizing equipment to a rolling equipment. The ability of the stabilizer to roll the vessel has been repeatedly proved, along the lines given in my 1915 paper on this subject.

We have now had opportunity to observe the behavior of the stabilizer under conditions of unusually heavy seas and upon yachts of different tonnage, and under all conditions it has abundantly proved its value and its complete control of the situation. This is well illustrated by the experience of one of the heavier yachts, coming north from Florida and suddenly encountering an extremely heavy gale. The enthusiastic report of the captain forms quite an appreciation of the services rendered by the stabilizer, and is given in his own language. He says:—

"We had run into this bad blow before I realized it. The seas were very short and steep and didn't give the boat a chance. She stuck her bow under and then when she finally lifted, the waves broke over her stern. She was rolling very badly, more than 45 degrees. As soon as we threw in the gyro, however, she quieted right down, and the strains and creaking that we heard in her ceased entirely.

When the gyro was on, she rolled only very slightly." (He gave three degrees as an occasional maximum.) "The two most surprising things to me were that the waves stopped breaking over her and that she seemed to steer herself. The helmsman found very little, almost no helm was required to keep her on her course, whereas before she was yawing, first this way and then that, to such an extent that a great deal of helm was continually necessary in a vain endeavor to keep her anywhere near her course."

The captain claimed the original discovery of these last two important advantages and expressed surprise that they had not been pointed out to him prior to the adoption of the stabilizer, as they were of such great value that they should not have been overlooked.

In northern waters and between Newport and New York on various trips, the stabilizer has been found to take care of ground swells and also quite heavy seas, while running at only fractional speeds.

Another yacht stabilizer, which has now been in service about a year, is on board the Aramis, lately owned by Lieutenant Commander Marks, and now taken over by the Government. This stabilizer is installed in the engine room (Fig. 7, Plate 52), with the control gyro directly above it, full view being thus afforded of the coordinated action of these two units.

During the trial of this equipment off Sandy Hook on April 25, 1917, weather well suited for stabilization was experienced and the curves on Plates 53 and 54 show how quickly the stabilizer quenched all roll as soon as it was thrown on.

The curves, Figs. 10 and 11, Plate 53, by their irregularities, serve to illustrate roughly one of my statements in a previous paper, that all rolling of ships results from a continual series of building up and then gradually dying down, caused by a succession of increments of opposite phase, which are due to the lack of synchronism between the natural period of the ship and the period of the waves. It is the possibility of handling these individual increments, by means that are not only extremely simple but perfectly persistent and reliable, that makes the active type of gyro successful in ship stabilization, and allows an immense amount of effective stabilizing control to be performed by a comparatively small and light unit.

These curves are drawn automatically by an extremely sensitive gyroscopic instrument, illustrated on Fig. 9, Plate 52, recording practically every motion that has an athwartship component. When the stabilizer is on, the ship is still seen to move, the movement, however, being confined to narrow limits. The question might be asked about this part of the curve—why is it not a straight line? The answer has to do with the fundamental law of all freely oscillating bodies, that is, when they are in the center of their oscillation, the directing or holding power of the centralizing force is zero. Thus it is that the directive power of the magnetic needle is zero when on the magnetic meridian. This is also true with the gyro compass when on the geographical meridian. It is not usually known that neither of these ever stands still, but that they imperceptibly hunt back and forth, crossing their respec-

tive meridians, reaching a point either side where the directive force rises to a magnitude at which it can head off the oscillation and return the needle back toward the meridian again. The same law holds true with a ship when in upright position, practically no disturbance whatever being required to cause the slight hunting movements that are seen to persist when the ship is stabilized.

It is also to be expected that the magnitude of these hunting movements of a stabilized ship will be proportional to the sea running at the time. This is shown in some of the curves; for instance, when the ship was rolling 31 degrees in a heavy sea, the hunting movements of the stabilized ship were somewhat greater than when the seas were milder.

The rolling records at the end of Fig. 17, Plate 55, give an opportunity for excellent comparison between the damping out of the roll by the gyro and the damping out of the roll due to skin friction of the ship itself, the maximum roll being the same in both instances.

Fig. 18, Plate 56, shows the 46½-inch gyro unit of the stabilizer for a 140-foot Diesel yacht now building.

Fig. 16, Plate 55, is the smallest stabilizer yet built and is for a 65-foot patrol boat. Due to the quick period of this boat and the fact that close stabilization is not required, the passive type of stabilizer has been employed.

Fig. 19, Plate 56, shows the gyro unit for the turbine yacht Isabel built for Mr. J. N. Willys. This ship is now being altered for work as a destroyer on the other side. Attention is called to the wheel for this equipment, Fig. 20, Plate 57, which proved to be a remarkably perfect steel casting, considering its size. This wheel was so perfectly homogeneous throughout and free from even the smallest blow holes that we were able to spin it directly up to normal speed as soon as it was assembled; and with almost no change in the balancing plugs it at once gave us perfect running conditions at top speed.

Fig. 21, Plate 57, shows the special roller bearings and adjusting rings that we have developed for use on all equipments up to those for 2,000-ton boats. The particular bearings shown are designed for a normal load of 40,000 pounds, but under test are found to take care of a 100 per cent overload.

Fig. 22, Plate 58, shows a stabilizer that went through most satisfactory trials aboard a slow ship of very unusual construction, which was coming north, in heavy weather, from Key West to Boston, the test running continuously for a number of days. This ship was accompanied by a fleet and was the only one to continue with the hatches open, with very little or no rolling. The sister ships labored heavily with hatches battened down, and rolling a maximum of 40 degrees.

Fig. 23, Plate 58, shows the six-foot stabilizer equipment just completed in our shops for a 1,500-ton naval ship. The complete equipment weighs slightly under fourteen tons and thus less than one per cent of the displacement.

Fig. 24, Plate 59, shows the rough casting in the foundry of the wheel of the largest gyroscope ever undertaken. In the rough this wheel weighed some 56,000 pounds. Very little balancing was found necessary to produce perfectly smooth

running at full speed. The casing for this gyro is shown in Fig. 25, Plate 59, while its main gudgeons were being machined in a large lathe. The very small relative size of the spinning motor is shown in Fig. 26, Plate 60, and even this is 100 per cent over size to permit of quickly pushing the wheel up to speed.

Fig. 27, Plate 60, shows the two gyros while the wheels were in the process of being balanced.

The comparative insignificance in size of the stabilizer equipment when contrasted with the ship it stabilizes is very adequately shown in Fig. 28, Plate 61. An arrow indicates the two stabilizer units, which are seen to be extremely small when compared with the ship's size. The equipment complete weighs about 80 tons, and the normal displacement of the ship is 10,000 tons; the stabilizers thus being only 8/10 of one per cent of the ship's displacement. This plate shows the stabilizers being passed into their compartment through the side of the ship in dry dock. The equipment operates in a small compartment connected with the engine room and under the engineer's direct supervision. A more intimate view of the gyros as they are being skidded into place is shown in Fig. 29, Plate 61.

It will be seen from the foregoing that there are gradually being accumulated valuable experience and data on stabilized ships under service conditions. An era has been ushered in when ships may ply the seas under conditions that are new and measurably superior to any heretofore possible. So little is required to persuade a ship not to yield her will to the seas, that the answer was not far to seek, it being one more of finesse than of force. The solution of the problem is in hand, and its application to a varied and wide range of shipping has been pointed out and illustrated. The foregoing pages recording the degree of success thus far attained in operating ships under the greatly improved conditions induced by stabilization.

DISCUSSION.

The Chairman:—I know you have all enjoyed this very interesting paper which has been presented by Mr. Sperry, and in your behalf I extend the thanks of the Society to him.

The secretary has a list of names of candidates for admission to membership in the Society, which have been passed upon by the Council, and recommended to the membership of the Society for election as members.

The acting secretary read the list of names of candidates:—

Members (18).

George Francis Adams, Sales Engineer, Room 416, 30 Church Street, New York, N. Y.

Fred. A. Ballin, Naval Architect, Secretary-Treasurer, Supple-Ballin Shipbuilding Corporation, Portland, Oregon.

Bertram Pierpont Flint, New York Manager, McIntosh & Seymour Corporation, 149 Broadway, New York, N. Y.

Edward E. Jenkins, Director of Purchases, the Foundation Company, 233 Broadway, New York, N. Y.

Frank Willis Grogan, District Officer, U. S. Shipping Board, Emergency Fleet Corporation, Commercial Trust Building, Philadelphia, Pa.

Norman Brierley Hall, Second Lieutenant of Engineers, U. S. Coast Guard, Acting as Inspector of Engineering Material (Aeronautics), U. S. Navy, care of Aeromarine Plane and Motor Company, Keyport, N. J.

Lewis A. Larson, Chief Draughtsman, Traylor Shipbuilding Corporation, 3857 North Kenneth Avenue, Chicago.

Chas. B. Look, Consulting and Efficiency Engineer; Office, 30 Church Street, New York, N. Y.

William Hugh McGrann, Commander, U. S. Navy, Retired. On duty at 280 Broadway, New York, N. Y.

Arthur Maxwell Mears, Mechanical Engineer and Naval Architect for Columbia Engineering Works, Columbia Engineering Works, Portland, Ore.

James A. Nelson, Representative of Union Plant, Bethlehem Shipbuilding Corporation, 111 Broadway, New York, N. Y.

William Thomas Peck, Construction and Consulting Engineer, 9 Lincoln Avenue, Atlantic Highlands, N. J.

William K. B. Potts, Assistant to Carroll S. Smith, Consulting Engineer and Representative, Wm. Cramp & Sons, 472 North 18th Street, East Orange, N. J.

William Henry Schott, Consulting and Contracting Engineer, 280 Madison Avenue, New York, N. Y.

Jas. Shewan, President, Jas. Shewan & Sons, Inc., Foot of 27th Street, Brooklyn, N. Y.

Edwin Arthur Shewan, Vice-President, Jas. Shewan & Sons, Inc., Foot of 27th Street, Brooklyn, N. Y.

John M. Sweeney, General Superintendent, Traylor Shipbuilding Corporation, Cornwalls, Bucks County, Pa.

Foster L. Hawkins, President, New Haven Shipyard, 296 Norton Street, New Haven, Conn.

Associates (2).

David F. Huddle, Jr., Inspector of Machinery, Electric Boat Company, Groton, Conn.

Frederick Mackle, Assistant Naval Constructor, U. S. Navy, Navy Office, Seattle Construction Company, 1907 Nob Hill Avenue, Seattle, Wash.

Junior (1).

David Joseph Howard, Ship Draughtsman, Preliminary Design Department, Bureau of Construction and Repairs, Washington, D. C.

Transfer from Junior to Member (1).

George Arthur Colley, Naval Architect, Lams, Lemoine & Crane, 52 Pine Street, New York, N. Y.

THE CHAIRMAN:—Gentlemen, you have heard the names of the candidates proposed for membership in the Society. Is there any objection? If not, all in favor of the election of these candidates say "Aye"; contrary-minded, "No." They are duly elected.

Has any member any business to bring before the Society before we adjourn? If not, the reading of papers to be presented at this meeting is now completed, and the only thing that remains to complete this meeting of the Society is the banquet to-night, which I am sure will be an extremely successful affair. It is expected that the Secretary of the Navy will be the principal speaker. He has promised to come, although he may be a little late in arriving, so if you do not see him when you get to the banquet do not think he is not going to be present, because he is expected. Mr. Schwab had promised to come and make an address, but upon his doctor's advice he had to give it up, and so our good friend Joe Powell is going to speak in his place. Joe is a splendid speaker, and you will be sure of a treat from him. The Rev. Dr. Eaton, who is wonderfully fine speaker, is going to make a patriotic address to-night, so that we may be sure of some very interesting speaking, and in addition there are to be some excellent musical features and also some very fine colored motion pictures, so that altogether you can look forward to the banquet to-night as a great treat.

I think we all feel that this has been a satisfactory meeting, and the record of our Proceedings at this meeting will be of great help to all of the members of the Society. The meeting is declared adjourned until to-night. I wish you all good luck until we meet again next year.

The meeting then adjourned.

RESOLUTIONS ADOPTED BY THE COUNCIL OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS, NOVEMBER 14, 1917.

Whereas, Congress has passed an act known as the War Revenue Act of 1917; and

Whereas, under Section 200 of said act it is stated "The terms 'trade' and 'business' include professions and occupations"; and

Whereas, Section 209 of said act states "That in the case of a trade or business having no invested capital or not more than a nominal capital there shall be levied, assessed, collected, and paid, in addition to the taxes under existing law and under this act, in lieu of the tax imposed by section two hundred and one, a tax equivalent to eight per centum of the net income of such trade or business, in excess of the following deductions; in the case of a domestic corporation, $3,000, and in the case of a domestic partnership, or a citizen or resident of the United States, $6,000, in the case of all other trades or business, no deduction"; and

Whereas, in most cases the professional man's earnings constitute his sole income, from which must be derived the capital which will yield a competency for himself and family; and inasmuch as these earnings are subject to the established income tax, including supertaxes, this same income should not be taxed further as if it were excess profits, when as a matter of fact it is not excess profits; and

Whereas, it is discriminatory and unjust to tax earned income at a higher rate than unearned income; and

Whereas, in other countries where incomes are taxed the tax is heavier on unearned than on earned incomes, thus encouraging industry and thrift;

Resolved, that in the opinion of the Council of the Society of Naval Architects and Marine Engineers, the provisions in Sections 200 and 209, hereinabove quoted, should be repealed because they are discriminatory and unjust.

Resolved, that the secretary be and he is hereby directed to publish the above in the Proceedings, and to send copies to the other national societies, and to the various associations of members, urging similar action. Also to forward copies to Hon. F. M. Simmons, chairman of the Committee on Finance of the Senate, and Hon. Claude Kitchin, chairman of the Ways and Means Committee of the House, requesting the repeal of the above-mentioned provisions at the next session of Congress. Also to urge each member of the Society to act individually by communicating directly with his representatives in Congress along similar lines.

New York, *January 30, 1918.*

To the Junior Members of The Society of Naval Architects and Marine Engineers.

Gentlemen:

Mr. H. L. Aldrich, Associate Member of the Council, offers the sum of one hundred dollars as a prize or prizes in cash for the best paper or papers written by a Junior Member of the Society for its annual meeting in November, 1918.

All papers submitted for such prize or prizes must be finished and delivered to the Secretary of the Society on or before October 15, 1918; and they shall be on subjects pertaining to the "Art of Shipbuilding, Commercial or Naval," the matter of power for driving ships being included.

The papers shall be delivered to the secretary without there being in any way any identification of the writers. Each competitor shall mark his paper with some sign of his own, which shall also be placed on a card bearing his name and address. This card shall be placed in a blank sealed envelope with no indication from whom the envelope comes.

This blank envelope with identification card enclosed shall then be placed in another envelope, bearing outside the name of the sender. This envelope shall be mailed to the secretary of the Society separate from the paper itself. All superscriptions on papers and envelopes shall be typewritten.

The judges shall be the Members of the Committee on Papers and they shall have the right to give the whole sum donated as a prize or to divide the sum into two or even three prizes as may seem best to the Committee, depending upon the quality of the papers submitted.

The object of the donor is to encourage the Junior Members of the Society to note the designs as well as all details of ships and shipbuilding, to develop ideas of their own in reference to the same, and to enhance the value of the Society to all interested.

Very respectfully,

(Signed) Stevenson Taylor, *President.*
Daniel H. Cox, *Secretary.*

TWENTY-FIFTH ANNUAL BANQUET

OF

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

HELD AT THE

WALDORF-ASTORIA HOTEL, NEW YORK CITY

FRIDAY EVENING, NOVEMBER 16, 1917

THE SECRETARY OF THE NAVY.
WASHINGTON

October 30, 1917.

My dear Mr. Taylor:

I have received your very gracious and courteous letter of recent date, inviting me to be the special guest of the Society of Naval Architects and Marine Engineers on the occasion of its annual banquet in New York on Friday evening, November 16th. Admiral Capps had already called to see me and I had told him that it would give me the greatest pleasure to come if it were at all possible, and we are planning to go up together. I am looking forward with great interest to coming and saying a few words to the Society, which is responsible for every important naval and merchant vessel built in the United States and which now has a larger field of usefullness than ever before.

Sincerely yours,

Josephus Daniels

Mr. Stevenson Taylor, President,
Society of Naval Architects,
No. 66 Beaver Street,
New York City.

TWENTY-FIFTH ANNUAL BANQUET OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS, HELD AT THE WALDORF-ASTORIA HOTEL, NEW YORK CITY, FRIDAY EVENING, NOVEMBER 16, 1917.

Mr. Stevenson Taylor, president of the Society, acted as toastmaster.

Before the service of the dinner, Dr. Frank Oliver Hall asked the Divine blessing.

After the service of the menu, the toastmaster, Mr. Stevenson Taylor, called the company to order and said:—

"Gentlemen, before taking up the regular program I wish to announce that Secretary Daniels is due here in a few minutes, and we expect him to speak to the toast of "The Navy." This afternoon he was detained in Washington and did not leave there until the 4.03 o'clock train. He will be here very shortly if the train is anywhere near on time.

"We had invited a number of guests, army officers and navy officers, to attend this banquet, but it is a little unreasonable to expect these men, who are so busy raising our Army and Navy to the efficiency desired, to come to a banquet. Still, we have with us a great many others in uniform, as you will see by looking around the audience and at the dais. We have with us several representatives of our allied countries, much to our pleasure.

"I want to read one letter that came declining an invitation. This will interest the members of the Society of Naval Architects and Marine Engineers especially. The letter is as follows:—

Department of Commerce
Bureau of Navigation

Washington, *November* 5, 1917.

Commander Stevenson Taylor, U. S. N. R.,

President, Society Naval Architects and Marine Engineers.

Dear Mr. Taylor:—Will you please accept my cordial thanks and convey them to the Society of Naval Architects and Marine Engineers for the honor of your invitation to attend as a guest of the Society its annual banquet on Friday evening, November sixteenth, at the Waldorf-Astoria.

I very much regret that my work here precludes me from accepting your invitation, for the occasion will be memorable. During the next twelve months the work to be done by the members of the Society of Naval Architects and Marine Engineers and by the organizations

and establishments which they represent will be one of the greatest, if not the greatest, contribution our country can make toward the defeat of Germany and the victory of our own country and the great free peoples with whom we are honorably allied.

May God speed you all in the great undertakings you already have and soon will have in hand.

Faithfully yours,

EUGENE T. CHAMBERLAIN,
Commissioner of Navigation.

"You will pardon me if, before we take up further the regular program, I refer to something that happened a year ago. Just a year ago to-night, a little before this time, a gentleman came in, walked around the table to me, shook me by the hand, and with his usual cheerful smile congratulated me on the fine appearance of our members at the banquet of the Society of Naval Architects and Marine Engineers. In turn I had to thank him for the encouragement that he gave us at one time when we were in a little difficulty about a place to have our dinner. I thanked him for that and told him that we had grown. He said, 'Yes, you are like the rest of our country; you will always grow.' Two weeks afterwards, the honored proprietor of this hotel, George C. Boldt, to my great regret, and to the infinite regret of many others who knew him better than I, passed away. I say these few words in his memory."

The first regular toast this evening is our usual one—

"TO THE PRESIDENT OF THE UNITED STATES."

The toast was drunk standing, and the "Star Spangled Banner" was sung by Miss Estelle Harris, accompanied by the orchestra, and with the waving of the Stars and Stripes.

THE TOASTMASTER:—Gentlemen, that toast has been the first and only national toast that we have ever had before in this Society. But much has happened recently. We are now allied with others, and I now give you the toast—

"HIS MAJESTY, GEORGE V, KING OF GREAT BRITAIN AND IRELAND, AND EMPEROR OF INDIA."

The toast was drunk standing, and Miss Harris sang "God Save the King," being accompanied by the orchestra, and waving the Union Jack.

THE TOASTMASTER:—It is manifestly impossible for us to mention in detail all of the great nations of the earth now allied with us. Let me epitomize them all with the next toast and La Belle France. I give you—

"THE PRESIDENT OF FRANCE."

The toast was drunk standing, and Miss Harris sang the "Marseillaise" amid the waving of the tricolor, being accompanied by the orchestra.

THE TOASTMASTER:—Gentlemen of the Society of Naval Architects and Marine Engineers, and guests, all—about two months ago I commenced to think of this banquet, and I made up my mind that we should have the banquet this year if never again. I talked it over with the secretary and he agreed with me. He talked with a few of our members and I talked with a few, and we came to the conclusion that it was the right thing to do. Then there came this wave of economy, and so many institutions began to give up their banquets that I wondered whether I had the right to say that the Society of Naval Architects and Marine Engineers should have its banquet this year or not, and to determine the matter we sent out word to the Members of the Council and asked their advice, in the meantime keeping up the preparations. The Council by a very large majority concluded that this year we must have our banquet, and so here we are. ["Hear, Hear."]

You will have noticed, those of you who have been with us for so many years, that at this twenty-fifth banquet of this Society the menu has been somewhat "Hooverized." I am waiting to see whether the hotel bill will be. [Laughter.]

There has been a wonderful change since we met a year ago. At that time I doubt if many people in this room—and there were not quite so many then as there are to-night—thought that this great country of ours would be at war before another year passed, but that ruthless submarine war begun last February 1st put us finally on our metal and we are at last in it. [Great and prolonged applause.]

Now, one of the developments of this war has been to bring to the minds of American citizens that we had no ships, to speak of, excepting our Navy. The political parties have played battledore and shuttlecock with the matter of an American merchant marine for a great many years. We have allowed our friends on the other side of the water, and particularly those of that nation which is now our enemy, to take from us what I consider was our right on the seas. It is very strange the attitude that a great many people have had about that particular question. We who have always lived on the coast, within sight of the salt water, have felt the need of a merchant marine; but the great middle west and the great northwest which I have heard lately termed as having been La Follettized, did not see any use for a merchant marine, and they did not know anything about shipping, and cared less. They felt that they produced their grain and other things that they wished to export, and that it was immaterial to them who transported those commodities; indeed, I do not doubt that they felt very much like one of the greatest shipbuilders in Europe who said to me, after some remarks of mine at the Jubilee Meeting in 1911 in London:—"My dear fellow, you have no right on the sea, you know. You know we take all of your goods from you, and we have the right to the transportation of them, but if you deliver the goods free of charge, then you have a right on the sea." I was bold enough to say to him:—"My dear sir, we will deliver the goods to you some day in our own ships, and you will pay the bill that day just as you do to-day." [Great applause.]

Now I have told that story once or twice before to good friends of mine from the other side, and they have insisted upon it that this gentleman was only joking, but I feel

that I know better; I feel that has been the attitude of the people on the other side—I am not speaking of one country particularly now, because the country of which that gentleman was a citizen has in the last twenty-five years allowed us to do anything, but they have allowed the country with which we are now fighting to increase its merchant marine regardless of any other question, and I think they were to blame quite as much as ourselves for that state of affairs.

However, it is not my purpose to discuss political questions. Upon this body of men present depends very much in the future. I see before me men who own shipyards, men who control shipyards for others, men who build ships and design ships, men who repair ships, men who are engaged in activities that are bound to keep the shipping business in this country busy in the next ten years beyond the dreams of heretofore. Do you realize, gentlemen, what you have undertaken to do, or what is to be put upon you?

Secretary Daniels has come in, and I will interrupt my remarks at this point.

(Secretary Daniels entered the banquet hall amid great applause and took his seat beside the toastmaster.)

The Toastmaster:—I had just come to that part of my remarks in which I think the gentlemen who have just entered this room, Secretary Daniels and Admiral Capps, will be particularly interested. I have just asked if the gentlemen present realized the work that had been put upon this group of men representing the shipbuilders and shipyards of this country. Admiral Capps has contracted for some 727 ships that I know of. Perhaps since I made this memorandum which I hold in my hand he has increased that very materially.

Admiral Capps:—We added one hundred more just before we left Washington.

The Toastmaster:—Eight hundred and twenty-seven, gentlemen. The 727 ships amounted to 2,550,000 gross tons, four and three-quarter times, and now, with the one hundred added, nearly five and one-half times the tonnage of the greatest production of the shipyards of the United States Coast and Great Lakes, taking the greatest production of any one year of each district; that is to say, taking the greatest production on the coasts in any one year in the last ten years; and taking the greatest production on the Great Lakes, which happens to be quite a different year; for putting these together, they amount to about 538,000 gross tons. The 827 ships now contracted for will amount to about 2,885,000 registered tons. These are to be finished within the next two years, and all in addition to the merchant ships under construction before these contracts were awarded and all in addition to the enormous increase to the Navy that our friend the Secretary of the Navy has already started. [Great applause.]

When you compare these figures with the entire capacity for building merchant vessels in the shipyards of the world in 1915 (3,685,000 tons) you will realize that there has been

undertaken a task truly worthy of American citizens like yourselves, and I have the utmost faith that you will carry it out; but let me sound just one little word of warning. I can only see really one great serious trouble that seems to arise like a cloud in the distance. I believe I can bank on every man in this room to do his part of this work. [Applause and cries of "Hear, Hear."] I know and you know that to the capital have gone many men of brains, of wealth and without wealth, who are endeavoring there and elsewhere to do their part in this great crisis, but there remains one question yet to be determined, the question of what will be done by that body which is usually termed "Labor." When four unions combined can figuratively grasp the citizens of the United States by the throat and say, "You must meet our demands or you cannot travel on the railroads of the country"; when other unions take you individuals by the throat and say, "You must do as we say or you will get no ships," then I say with all due deference to those in authority, that question must be met and must be solved and solved rightly. [Great applause.]

There is another feature I would like to see discontinued, what I may call the camouflage that is almost daily published. For instance, we see great headlines, "An Inventor Would Convert 2,000,000 Tons of Sailing Ships into Steamships." [Great laughter.] The newspapers say further that the inventor would convert 2,000,000 tons of sailing ships into steamships by installing twin-screw engines. The "inventor" does not realize that you have undertaken to build marine engines of more horse-power, and all of the necessary auxiliaries in addition to those under way than the whole production of that great marine factory, Great Britain, in any year. Such statements deceive no one who possesses real knowledge of the subject. They only deceive the great suffering public, and when the time comes that they find these "mad promises and baseless expectations" are not realized, there will be trouble. I beseech you gentlemen that deal with labor, that deal with all of the questions that arise daily, by the minute, indeed—I beseech you, as loyal citizens, as men who believe in, and stand behind, the President of the United States, to do your part in solving all of the difficulties that come before you. I am sure you will. [Great applause.]

The day before yesterday in the *Boston Herald* appeared this sentence:—"We shall build ships; we shall secure and train officers and sailors; we shall perform this gigantic task more rapidly in all the circumstances than could any nation in the world, for the sea was in our father's blood and the ocean is our birthright." [Applause.]

Just a few words in conclusion, to those representatives of our allies who are present. America has taken a great stride in a short time, and now she offers all of her resources, her millions of men, and her magnificent Navy in service to the allied nations of the world against the Hun. [Applause.] Gentlemen, the people of the United States of America are on their way, are on their way. [Applause.]

Our next regular toast has usually been divided into two parts, but, as I have already explained to you, the army officers are too busy at the camps in our neighborhood to spend their time at a banquet, and I know you will think that is a good excuse. The naval officers who usually honor us from our own navy yards and fleets are busy in just exactly

the same way, but we have a splendid substitute, if he does not object to that word, and I do not believe he will, and to respond to our next toast—

"Our Army and Our Navy."

I will ask the Secretary of the Navy, who is responsible for the greatest expenditure on account of the Navy of any Secretary of the Navy we have ever had, and who to-day transacts the business of his office so rapidly that it is a pleasure to deal with him. I have great pleasure in introducing to you the Honorable Josephus Daniels, Secretary of the Navy.

ADDRESS OF HONORABLE JOSEPHUS DANIELS, SECRETARY OF THE NAVY.

Lieutenant Commander and gentlemen, when I received the invitation to be present to-night from your distinguished president, whom I am glad to say is a distinguished officer in our service [applause], I said, "Aye, aye, sir." In fact, in these days when we are enrolling in the Navy so many skilled men, and when rank is changing from month to month, I never dare disobey the command of any naval officer. Two weeks ago a distinguished admiral from Great Britain came to America, and when he visited this city he was introduced and welcomed by a distinguished American, Lieut. Commander Truman Newberry. [Applause.] The same admiral had visited this country once before when Mr. Newberry was Secretary of the Navy, who then outranked the admiral. In coming here I feel that I am not departing from a rule that I have been compelled to lay down for myself during this war, to attend no gatherings except naval or kindred patriotic gatherings. In these parlous times I am almost as busy as a shipbuilder, and if I have an hour to spare, Mr. Powell or Mr. Ferguson or some other shipbuilder does me the honor to take that hour.

Almost every morning we read in the headlines of the papers a statement of what will win the war. If it chances that Secretary McAdoo is being quoted, he says that money will win the war, and we subscribe for more Liberty Bonds than we are asked to take. If Mr. Hoover is speaking, he tells us that food will win the war and we gladly agree to meatless and wheatless days. I suppose that you had a meatless and wheatless banquet to-night. I am sorry I did not come in earlier so that I might have enjoyed it. If you ask Mr. Willard, Chairman of the Transportation Committee, he tells you that the railroads will win the war, and so it goes. I am glad that all of these gentlemen magnify their departments and make us understand the problems and the various duties that rest upon us in this crisis of our Republic. But you know, and I know, that ships will win this war. [Great and prolonged applause.] The farmer tills his acres and he has our gratitude for larger crops; but unless we have ships, these crops can neither feed our soldiers "over there" nor feed our allies who are fighting in this great struggle. [Applause.] And so it is you and your associates who are charged with the greatest responsibility, the most difficult task, the most gigantic undertaking ever put upon the shoulders of any body of men in the history of America. You must provide the ships without which we cannot win the war.

We see by the current accounts that the submarine menace has reaped less ships in the past week than at any time since the high-water mark in submarine destruction in April last, and we have no doubt that the genius and the enterprise and the skill of our shipbuilders, in this country and abroad, will defeat that menace, but let no man minimize the menace nor the difficulty of building ships. It is our duty to meet these great responsibilities.

We have entered into this war because the very principles upon which our fathers founded our government are at stake; we have entered upon it soberly, earnestly, and with a firm determination to do our part to win victory if it takes the last man and the last dollar. When our people made that firm resolve, the problem of building more destroyers was one of the most serious problems we had to meet, for it had become apparent to all that the destroyer was the best known defense against the submarine.

We immediately consulted with those shipbuilding concerns which had been building destroyers, and found that every facility in America for building them was being used for the program already authorized. But the shipbuilders came to Washington and after the plans for additional destroyers were discussed they said:—"We can do it." They have already begun and they will do it. [Great applause and calls of "Hear, Hear."]

The spirit of these gentlemen is the same spirit that was expressed by the senior officer of our destroyer force when the first destroyer sent from this country to Europe reached a foreign port. The admiral of the English Navy met the officers of the destroyer and after giving them cordial welcome said to this commanding officer, "How soon will you be ready?" The officer replied, "We are ready now!" [Great applause.] He was expressing the American feeling and determination not more courageously nor more bravely than Mr. Powell and Mr. Ferguson and the gentlemen of Cramps, Bath, Union Iron Works and the New York Shipbuilding Company expressed it when they agreed to increase their facilities and add more destroyers in a year and a half than we had built in twenty-five years. [Applause.]

I knew and they knew it was an impossible task unless they could have behind them the resources of the Federal Government, and unless they could have the cooperation of the men who had auxiliary plants and could stir the enthusiasm and get the cooperation of skilled labor in this country. To that task more than any other the Navy is now addressing itself, and I have no doubt we shall succeed, but it is an undertaking so big that this is not a time either for optimism or for pessimism, but for resolution. [Applause.]

About a year ago a Committee of Congress called on the President of the United States to discuss with him a measure pending in the Senate in which he was greatly interested and the passage of which was vital to our country. The committee talked for half an hour about the difficulties of the situation, and when they had finished the President said:—"Gentlemen, for half an hour you have been telling me how you cannot do it. Now let us talk about how we can do it." [Loud applause.] And, strange to say, it was done the next week. The shipbuilders, knowing the difficulties, knowing that it would take time and stress and effort and sacrifice, did not talk to me for five minutes about how they could not do it, but they said, "Let us plan how we can do it," and that is the spirit which has been manifested everywhere. [Applause.]

My distinguished friend, Admiral Capps here [great applause], a member of your organization and one of the great men in a great profession [great applause], with his associates, has a job bigger than was ever put upon any man before in the history of our couutry.

You have spoken, sir, of the ease with which men who do not know anything about the

business talk about building ships and launching them before breakfast. [Laughter and applause.] You know it is a giant's task; you know you cannot build ships in a day; but that board and this distinguished admiral are bending their energies in cooperation with you and your associates to the end that every ship that can be built will be launched as soon as possible. [Great applause.]

In that task all America must unite. There was a time when we thought war was a matter of men and guns and ships. The nation today is mobilizing for war, and we have no chance to win this war unless America is united as one man. [Applause.] Let us all here and now, both in public life and in private life, highly resolve that, cost what it may of effort and of sacrifice, this great program shall be finished, these ships shall be furnished, and this war shall be won. [Prolonged applause.] I spoke of those of you who are in private life. I wish to withdraw that. There is no shipbuilder today in America in private life. You are all enrolled and mobilized of your own choice in this great undertaking. [Applause.]

There can be, gentlemen, no compensation for the tragedies of war. Its shadow falls upon every community, I pray God it may not fall upon every home, but it would be a thousandfold better that it should fall upon every home in America than that liberty should perish from the face of the earth. [Great applause.] Freedom hangs in the balance. Those who are fighting against the principles that Jefferson set forth in his Declaration, and Washington won in the Revolution, and Lincoln preserved in the sixties must be overcome. [Applause.] The perpetuation of the principles of this free government, and of all free governments, depends upon your sacrifice and my sacrifice and the willingness of America to put everything on the altar. Are we ready to do it? [Cries of "Yes, yes."]

I said that there can be no compensation for the tragedies of war. But there may be several things that come to a people out of the sacrifice of war that may lift them up and ennoble them and purify them. The first of all is the unity of the people. Before this war came I fear that many of us had forgotten the simple faith of our Republic. The love of ease and pleasure seemed to be dominating many of our communities, the greed of gain had warped noble lives, and the divisions among us did not give to America that solidarity and strength which she ought to present to all the world. This war has brought unity. This war has brought men shoulder to shoulder, touching elbows. Think of it to-night, how the small questions that divided us a twelvemonth ago are considered trivial and forgotten and despised. We now think only of the great questions that stir men's hearts, the protection of our homes and the protection and perpetuation of free government. [Applause.]

When Mr. Jefferson was inaugurated President, he came into office at the time of the first rancorous and bitter political campaign in our history. This city then, as always, was a great battleground, and the two parties were pretty evenly divided. We read to-day of the very vicious things which partisans say of each other, but if we should go back to the campaign of 1800 we would find that what has been said in these later days is very mild indeed. Mr. Jefferson in his inaugural address used these words:—"Every difference of opinion is not a difference of principle." He said further, "We are all Republicans; we are all Federalists."

To-day in America we can truly say, "We are all Democrats; we are all Republicans." [Applause.] Partisanship has developed into patriotism, and one of the compensations of this war is that we have learned to know that the brand of politics does not tell the brand of patriotism, but that men of all parties alike are responding to the call as American citizens and not as partisans. [Great applause.]

We have this unity in religion. I heard a distinguished minister say a few nights ago —he was a distinguished Baptist preacher who believed that we all ought to go down under the water—"I have quit trying to make Baptists since this war began; I am trying to make Christians, and militant Christians who will fight for America and their religion." [Applause.]

Another compensation is that we have forgotten sectionalism. We are all Americans. We are training our boys in Camp Grant and Camp Lee, thank God, to fight for the same cause. [Great applause.] We have come also to a broader unity in international affairs. Before this great war came most of us thought in terms of the United States. We did not know much about the politics or geography of the world, and many of us cared less. To-day our brothers in war are in Japan, sir (turning to a Japanese naval officer who was a guest) [applause], and we have toward that nation a feeling of friendship and amity which was born when a great naval officer, Commodore Perry, visited your country. [Applause.] On every Fourth of July for more than a hundred years we have praised the American eagle and twisted the British lion's tail by way of diversion. We now see eye to eye with Great Britain and stand as brothers in a common cause for the supremacy of liberty and free government. [Applause.] We never had to learn to love France—it was born in us. To that country, which has suffered most in the stand for liberty, our feeling is expressed in the words of Benjamin Franklin:—"Every man loves two nations, his own and France." [Applause.]

We are brothers of the struggling nation of Belgians, who, when the German Emperor demanded passage through their country, replied, "We are a country, and not a road." [Loud applause.] We are brothers of the struggling Italians, stopping the march of the Huns towards the Imperial City. We are brothers to Portugal and to all of the countries allied in this great struggle for liberty, and I would lose my faith in God if I doubted that these nations would win the supreme struggle for humanity and liberty. [Great and prolonged applause.]

We have the compensation also that men and women are working together in this country as they never worked before. They are united, more than ever since New York voted for woman suffrage. [Laughter and applause.]

A few days ago a gentleman in Washington chanced to pick up the notes written by a colored preacher for the sermon he was going to preach on the Sunday morning before the canvass for the Liberty Loan bonds ended (you know that the great Government asked the preachers to help out in that great cause), and the notes read like this, under three headings: —"There are three kinds of bonds: The first is the bond of matrimony, which we endure;

the second is the bond of slavery, from which we have escaped; and the third is the Liberty Bond, which we are all going to take. [Laughter and applause.]

There is another compensation, a compensation not fully realized, but a compensation that will come through mutual concessions in behalf of patriotism. We have a better unity between capital and labor than we have ever had before in America. Applaud that. [Great applause, participated in by Mr. Daniels.] This is not the first time I have had to applaud my own speech.

Gentlemen, Sir Stephenson Kent, a distinguished member of the Munitions Board in Great Britain, visited our country recently, and gave us more illumination about the particular problem we have in hand than we have obtained from any other source. That manufacturer, a man of wealth, whose heart has always been in sympathy with men who toil, told us that in the early days of the war one of the serious things the British encountered was the fact that, while the men were speeding up the work, a few munition factories declared 200 per cent dividends. Now, gentlemen, we are going to have unity between capital and labor, and we are going to secure it by believing in each other and forgetting hasty actions and hasty remarks. [Applause.] We must make concessions, we must have faith, and we must meet conditions as they arise, knowing that when we deal with millions of men it is not a problem which can be solved by a simple rule of thumb. You pick up the morning paper and you see there is a strike at some place and ten thousand men are out, and you lay the paper down with a feeling of hopelessness; but you do not see any statement in the paper that ten million men in America are doing excellent work and are not striking. [Applause.] You read some day that one manufacturer has refused to consult with his employees, but you do not recall that 90 per cent of the employers are glad to meet their men half way.

Let us get the true perspective. Men who are building ships in this country are doing just as loyal and patriotic work as the men who are serving in the trenches, and men who have capital invested and who are putting brains into their business must be insured fair returns for their work and for their capital. [Applause.] But, gentlemen, there is no place in America to-day for any profiteering. [Applause.] There is no place in America to-day for men who stop the wheels of government because they cannot have their way with labor. [Applause.] It is a very easy thing, comparatively, for us to settle problems of steel and iron—if we can get the iron and steel—but the human element is a very much harder proposition and is much more difficult to deal with. We must remember that the men who toil in the shops and build these ships are American citizens and must be dealt with as American citizens. I have found them sometimes unreasonable men. Confidentially, I have sometimes found capitalists unreasonable. [Laughter and applause.] In this hour no man has a right to think of himself, whether he owns a shipyard, is Secretary of the Navy, sails before the mast, or works in a shipyard. We are all Americans, and we ought to forget money and salary and wages, and work for the country, and be thankful for the privilege. [Great and prolonged applause.]

When I see, as we have seen recently, more than two hundred thousand lads in America,

over eighteen years of age, most of them under twenty, going into the Navy, putting their lives in jeopardy, and many of them giving up important business positions for thirty dollars a month, I would be ashamed of myself if I thought about a dollar for myself, staying at home, and not going into the trenches or on board a ship. [Great applause.] I know that the feeling I have is the feeling which dominates you. But I have already spoken too long. [Cries of "No, no."] I might have to applaud myself again.

Gentlemen, what I came here for to-night (because, as I said, I am so busy I have not been to a dinner before, except a Hoover dinner, in nearly a year—and I missed this one), what I came here for was to thank you gentlemen, on behalf of the Government, that you have enlisted in this war. For unless the shipbuilders, the naval architects and the marine engineers, and the men of the allied professions stand firmly with the Government, these large programs are impossible. I wish to thank you for the spirit you have shown. I wish to thank you for what you have accomplished, and I wish to say that when this war is won —as it will be as surely as God rules [great applause]—and there shall march through your city and on to Washington a victorious army and a victorious navy, I shall insist that in that army, in a place of honor there shall march you, gentlemen, and those who work with you, who will make victory possible. [Great applause.]

The Toastmaster:—Mr. Secretary, on behalf of The Society of Naval Architects and Marine Engineers and their guests, I extend to you our heartfelt thanks for this speech of yours and for your attendance upon this occasion.

Secretary Daniels:—I thank you, sir.

The Toastmaster:—It was my pleasure, on your behalf, to invite as a guest at this banquet this evening the Honorable Edward N. Hurley, Chairman of the United States Shipping Board and President of the Emergency Fleet Corporation. In a very polite note he declined, claiming, of course, very naturally and very properly, that the business of his office took all of his time, and that he had no time now to make an address at a banquet. Between the lines I read that he did not want to make an address. So then I wrote down to the General Manager of the Emergency Fleet Corporation, and asked him to prevail upon Mr. Hurley to at least come here, and I would promise not to ask him to make a speech; but I did not promise not to ask the General Manager of the Emergency Fleet Corporation to speak, and I know as one of the few founders of this Society twenty-four years ago, as one of the leading spirits of this Society during the whole twenty-four years, as one who has rarely, if ever, missed a meeting of the Society until yesterday and to-day, he must have a few words to say to you, and I call upon you to receive, as usual, our old friend, Admiral Washington Lee Capps. [Applause.]

ADDRESS OF REAR ADMIRAL WASHINGTON LEE CAPPS

Mr. President, our guests and fellow-members, it is hardly fair to embarrass your old colleague by presenting him immediately after his chief, who has so thoroughly and justly aroused your enthusiasm through the very forcible and felicitous way in which he has set forth the problems that we are facing, and our determination to meet them, and to win. There is also another embarrassment, because the Secretary of the Navy does not travel nowadays without an official censor. *He* can control the censor, but *I* cannot. Therefore I have to be very guarded in what I say. [Laughter and applause.]

It is with very great regret on my part that I am substituted for the President of the Emergency Fleet Corporation. I should very much prefer that he should be here to speak for himself, as he so well can. Unfortunately, he got away from Washington before I did to-day. The Secretary of the Navy might have escaped too, had I not insisted on coming on the same train with him; but the other gentleman got an earlier train and then telephoned me here that he was not feeling well and could not come. Now you see exactly what I am up against.

I wonder if, in the meetings we have had here in the last two days, there have been any allusions to the fact that while this is not the twenty-fifth anniversary of the founding of the Society, it is our twenty-fifth annual dinner. Anyhow, that fact brings to my mind very vividly the first dinner of this Society twenty-four years ago in the old Brunswick Hotel. There were less than one hundred members and guests present, and the then Secretary of the Navy was one of the latter. A large proportion of those who were present at that dinner I note with great regret are not with us now. But there are here to-night many men who knew many of those who were then present, and who loved them. Among the speeches made on that occasion, which, I may say, was very largely a "family affair," there were two that impressed themselves upon my mind forcibly. One was a delightfully reminiscent speech from our dear old friend, Andrew Fletcher. Mr. Fletcher was really the Nestor of marine engine builders in those days, and, in his simple, forceful way, he described how he and his staff constructed the first of the group of marine engines which subsequently made the name of that firm famous. Some one quizzed him and asked a modern technical question, and he turned and said, "In those days, if we had a cold chisel and a hammer, we could smooth down any slide."

Dear "Uncle Andrew" had hardly sat down when the presiding officer, the late lamented Clement A. Griscom, turned to me—I was the unfortunate secretary in those days—and said, "Don't you think that 'Uncle Charley Haswell' ought to tell us something?" Several of the gentlemen around us heard the remark and said, "Certainly." It should hardly be

necessary for me to say who "Uncle Charley" was, but there may possibly be some here who do not recall that "Uncle Charley Haswell" was engineer-in-chief of the Navy, before anybody now here was born, and he left us only a short time ago, having almost completed his five-score years. He was the first chief engineer in the U. S. Navy, and was made engineer-in-chief in 1844. When called upon, "Uncle Charley" "allowed as how he would be willing to say something." As he rose, he reached into his pocket and pulled out a great roll of manuscript, and Mr. Griscom said, "Great heavens, I came near overlooking a real speech." [Laughter and applause.] Then we were regaled with some very choice anecdotes of how they made and ran machinery in the early days of marine propulsion. Those who were there will not have forgotten it, I know.

Then another member arose, the worthy scion of a most distinguished shipbuilding family. As he is living and is possibly here tonight I will not embarrass him by naming him, but he told us how, on the trial trip of one of the early steam vessels, the fireman rushed up on deck and shouted that "somebody had smashed the condenser and the vacuum was running all around the fire-room floor."

These are merely some reminiscences of that little company of sixty or seventy persons at our first dinner. Since that time our banquets have become annual events to shipbuilders throughout this country, and when I say shipbuilders, I mean everybody who has anything to do with the building of ships. That includes, of course, nearly everybody who has accomplished things in our shipbuilding and shipping world.

To-night, as this crowded hall indicates, we have, I should say, one of the largest gatherings in our history. It is quite a notable night for those of our profession. It is the first time that we have come together since America entered this world struggle; and, gentlemen, while it is a great pleasure to be with you and while we may indulge in pleasantries and the other things that accompany after-dinner remarks, I really did not come all the way from Washington to be with you for an hour or so and to indulge only in reminiscences concerning things which happened nearly twenty-five years ago.

May I beg your indulgence therefore if I say a few words of a very serious character concerning the work that is now very close to all of us? It is all very well to say that we will build ships, that we must have ships, and that the necessary ships will be built. To produce ships, however, requires earnest, concentrated effort. It requires complete and hearty cooperation between the men whose manual dexterity actually builds the ships, the men who design and supervise the building, the men who supply the capital, and those in public life who, in a legislative or administrative way, control the whole operation. At the present time the Navy Department and the Emergency Fleet Corporation are the two agencies of the Government which practically control the whole shipbuilding industry in this country.

In the last few months it has been my fortune to have been brought in very intimate contact with many of your troubles. In fact, one sometimes thinks there is nothing but trouble—because surely, if anybody has any shipbuilding difficulty and does not bring it to

the attention of the General Manager of the Emergency Fleet Corporation, there must be something wrong. But difficulties in this life are only created to be overcome. Of course we have our troubles and we will continue to have them, but we can surely overcome all obstacles if we go at them in the right way, with the right spirit, with the determination to conquer and remove them. The same grim determination which, on the battlefield, carries a valiant army through the enemy's lines will carry you and me through our difficulties in creating this fleet which is one of the prime requisites in winning this war. And for us to win this war is absolutely essential for the continuance of all that we hold dearest in our civilization. I am sure I am not putting the case too strongly by stating it in this way.

At the very outset, in many of these difficulties which confront us, we recognize the influence of previous industrial misunderstandings. Both labor and capital introduce complications. Labor does not present its claims for the sake of introducing complications. Far from it. In the vast majority of cases it thinks it is not being treated fairly, or else is not getting its proportion of what it believes to be the profit resulting from its handiwork. The employer often has quite a different point of view, and misunderstandings and cessation of work ensue. Much of the trouble in this world is due to misunderstanding. Charles Lamb on one occasion was speaking somewhat severely of one gentleman to another. The one to whom he was speaking happened to be a great friend of the one criticised, and he turned to Lamb and said, "Charles, do you know this man you are abusing so roundly?" "No," said Lamb, "I never could abuse a man I really knew." That, unfortunately is the attitude, unconscious though it may be, of most of us. If we could only get together and look at things eye to eye, I think a good many of these problems of employer and employee and administrative official would be solved much more readily than they have been in the past.

I mention such a subject reluctantly—I know that it has dynamic force and is subject to explosive effects. But I also know it is something of great importance and in our minds very frequently. I am therefore touching upon it as, in my opinion, a public duty, because in the last few months I have had to deal with this subject very often, and it is possible that such action as I felt compelled to take pleased neither side. At all events I tried to be just and impartial, and one fact above all others has impressed itself upon me very strongly—that, in carrying this great shipbuilding work to a satisfactory conclusion, a rapid conclusion, we have to forget self entirely. The man who supplies the capital, the man who administers and supervises, and the man who supplies the work of his hands must fully realize that it is not a question of what they mutually receive from this work, but rather a question of what they give and of their ability to *serve* the nation to the fullest extent of their powers in this great crisis. And it is indeed a great privilege to give such service. The Secretary of the Navy has just referred to the men who enlist at thirty dollars a month and offer their lives for their country. Can there be any service more complete or more glorious than that? And shall we, in our work, haggle over the terms under which we shall do our part—we who are in absolute security, near our own firesides with everything at hand that goes to make life comfortable? I say it, and say it in all seriousness, that we must arouse ourselves and

realize that never before in the history of the world has any one profession, any one business, had so glorious an opportunity to do such a tremendous work in this world's war as has the shipbuilding community of the United States of America. It is a wonderful opportunity. It is a glorious privilege. Let us do well our part. The prediction of ships being built at a certain rate means nothing whatever unless you put your whole power, and nerve, and ability, and heart—everything you have—into accomplishing this work as a great national task. [Great applause.]

Do not let us have any misunderstanding as to the terms on which the work is to be done. Those who have the direction of such matters can be easily criticised; sometimes, it may be, justly. But do not forget that at the bottom of all of this determination to do things, in what is believed to be a wise and just way, lies the broad, fundamental idea—that these vast expenditures must be made wisely and with a view to rapidity of production and adequacy of return. Both labor and capital are deeply concerned in the results. Difficulties are sometimes encountered where difficulties should not exist. There are those who have an idea that excessive profits are being made throughout our shipbuilding world. We know that in the majority of cases this is not true even though, in exceptional instances, such a belief may have justification. But the man in the street does not always look at the average; he sometimes looks at the isolated case, and he assumes that others are deriving great profit, and he also ought to have his share. Now, in time of war, in discharging these great public trusts, we must be even more punctilious than in times of peace to see that the expenditure is wise—not for the mere saving of the dollars involved, but that this nation may realize that, in giving up its substance to be expended for the national good, that substance is being expended wisely. And here, let me add in all seriousness, all sincerity, it is not a question of *profit* which any of us should be considering in these days—it is rather a question of winning the war. For, unless we win, nothing else is of consequence.

Now let us get this idea firmly into our minds—I know most of you have it there already. In this struggle, where performance is the only thing that counts, it is up to every one of us to contribute every ounce of everything he has, whether it be brain power, hand power, wealth or any other force, in order that the Government may go ahead and do its full share in this colossal task to which the United States has been assigned so large a part, especially in the building of ships—naval, troop transport, and cargo carrying.

As our Secretary of the Navy has most truly said, those of us who do work in that way are just as surely doing our share as the men in the trenches. But we do it under easier conditions, and therefore we should not make any serious question as to the terms under which we do it. Let us resolve here to-night that this Society, which represents practically all of the shipbuilding industry in this country, will grasp this magnificent opportunity for service, and that we will give every possible cooperation to those who are striving in Washington to do their share. And, finally, let us all see to it that the things which are expected of this country in the way of overseas transportation and overseas protection will be given, given promptly, and in such measure that this war will be absolutely and completely won and in the shortest time possible. [Loud applause.]

THE TOASTMASTER:—I wonder if I dare tell a couple of anecdotes of the Fletcher period. A good many of you know that I was raised under Mr. Andrew Fletcher. We had a little three-story brick machine shop on West Street, which extended back about a hundred and fifty feet, and then at right angles into Vestry Street, where we had the boiler shop. For many years that concern did the work on the Inman line of steamships. When they commenced to do these repairs the steamships ran once in every two weeks, and after awhile once a week, and it was the business of that little shop to keep these steamships going. Mr. Inman came to the shop one day and stood out in front of the three-story brick building and looked up at it—it was the only time that Mr. Inman called—and Mr. Andrew Fletcher, of whom Admiral Capps has spoken, just came out of the door and he asked him if there was anything he could do for him. Mr. Inman replied, "Yes, my name is Inman, William Inman." Mr. Fletcher said, "Oh, Mr. Inman, come right in; glad to see you." "But is this the shop that does the work for the Inman line?" "Oh, yes," said Mr. Fletcher, "come right in." Mr. Inman said, "But it is a very small shop for such very large bills." [Laughter.]

One other anecdote comes to me at this time—we had a visitor from California. We had built several engines for the Pacific Coast, of fairly good size, 50-inch diameter of cylinder and 11 to 12 feet stroke, and this gentleman walked down and looked at this three-story brick building and passed on. He came back and Mr. William Fletcher, Mr. Andrew Fletcher's older brother, happened to meet him that time, and he said, "I am looking for Fletcher, Harrison & Co." "This is it, sir." "Oh, yes, but you have another shop than this?" It so happened that a few months before that we had engaged a good sized machine shop down in Beach Street. Mr. Fletcher said, "Oh, yes, we have another shop in Beach Street." "That is where you have the large tools?" "Yes," replied Mr. Fletcher, "we have a hydraulic jack and a three-legged gin down there." You see that we built our engines in those days on the sidewalk mostly, but I am very proud of my forty years with Fletcher, Harrison & Company, W. & A. Fletcher and W. & A. Fletcher Company, of which I was a part so long.

Now there is a very important question before you, which has been before you, and I intend to keep it so. That is why I invited the Secretary of the Navy here, and why I asked Admiral Capps to speak to you, and that is the question of ships and shipbuilding. A number of years ago it was my good fortune to have something to do down at Cramps, and I met a young naval constructor down there who had recently become the assistant to the president of that company, and one morning I suddenly discovered that this young man had been boosted into the presidency of a large shipbuilding corporation. Just a few days ago I read that this same young man had been made the vice-president of a very much larger corporation, and had been placed in charge of Sales and Operations. I cannot imagine anything larger than that, and I began to wonder,

> "Upon what meat doth this our Cæsar feed,
> That he is grown so great?"

I do not mean to tell you men who know this young man. I give you as the next toast,

"SHIPS AND SHIPBUILDING,"

and it is with great pleasure that I introduce my dear friend, Mr. Joseph Wright Powell. [Applause.]

ADDRESS OF MR. JOSEPH WRIGHT POWELL.

I think our distinguished president, my friend, Mr. Secretary, was poking fun at me because I told him this was the first meal I had taken for a week, except a little toast. Seriously, gentlemen, I asked nine people before I came here to-night to tell me a new story, and the newest story I got was old enough to vote when I was born. I do not know just what has happened to the crop, but anyhow as I sat here to-night, the solemnity of this occasion and the burden of the responsibility that it is up to us to carry has put all of those stories very far from my head. It is a great disappointment to me that Mr. Schwab was not able to be here to-night. His physician ordered him south only three or four days ago, and your president then telegraphed and asked me to take his place.

You remember that a large delegation called on Daniel Webster once to get him to go to their home town to make a speech. Daniel Webster asked them how long a speech he was to make. They said, "Why do you ask?" "Well," he replied, "if you want me to talk an hour, I can go back with you to-night. If you want me to talk for half an hour, I want a week to prepare; if you will only give me ten minutes, I cannot talk to you before next month." I have only had three days to prepare, and the subject of ships and shipbuilding is big enough for me to talk about for a long time. Of course, we are, each of us, to-day so busy in our particular little nook and cranny in this business that we are a good deal like the hardworking bricklayer, who every morning and night carries his bricks up the ladder and his empty hod down again. He does not see much but the wall he is working on, and sometimes I think, when I get time to think about the general situation, that we are a good deal like that bricklayer. The possibilities of this situation are so enormous, and the events that may befall on any day are so beyond the reach of the human mind, that it is, after all, of little use to those of us who have our work clearly cut out to do, to give too much time to idle speculation.

When this subject was first handed to me it seemed to me it would be an extremely easy one to talk about, but as I have thought about it in the hours that have gone by, it has been clearly borne in upon me that this is no time for destructive criticism, and that if anything is to be accomplished it will be through the suggestion of some means that may tend to the one common end that is actuating every good American citizen to-day.

In thinking about the subject, it is most natural for me to think first of the Navy; and, gentlemen, I want to say right here that if any one of you had said seven or eight months ago that to-day the preparedness program of the Navy would have advanced to the position that it occupies, there is not one of us but would have thought that he was making an absolute misstatement. And, Mr. Secretary, I want to say to you here that what you have done, and what your efficient lieutenants, the Chief Constructor and Chief Engineer, Admiral Earle

and Admiral McGowan, have accomplished in these few months, is little short of marvelous. [Applause.]

I want to cite just one instance, because there is not very much of the details that we can tell about, but it took just two sittings of a total of less than four hours to conclude the biggest single contract that has ever been let in the history of the world; and I want to say, moreover, that that contract will stand as a model of effectiveness and efficiency for producing, both to the Government and to the contractor, the returns that each of them must have under these conditions.

The desire to achieve results, the desire to deal fairly with the parties to the contract, the desire to get the best that is in every one coming in contact with the Department, has made it a pleasure to each and every one of us to go to Washington with our troubles, and if I sometimes steal away a single hour that the Secretary finds he might give to other things, I must plead that it is because he is so courteous and so ready to listen to what seems to us of great importance, that we take many troubles to him he might not otherwise hear of. [Great applause.]

Now I am particularly pleased to pay this tribute to the Secretary of the Navy, because it was only about nine months ago that, with some of my brother shipbuilders, I was haled before the House Committee on Naval Affairs, to explain some extravagant charges that we were supposed to be aiming to extract from the Navy Department in connection with battle cruisers.

The last time I had the pleasure of speaking from the same table with the Secretary—he left the hall before I spoke—the subject given to me was "Shipbuilders and Their Relation to the Navy Department," and I found it necessary at that time to make, as I believed, some criticism of the arm's-length way in which the contractors were at that time being treated by the Navy Department. It seemed to me even then that this war was so inevitable, and that the necessity that the nation would find itself under to use the very best efforts of the shipbuilders was so apparent, that the relations between the two parties should have been much closer. But I want to say to you that to-day, and I think all of you who are doing business in Washington will most heartily second me in what I say, that no better relationship could exist than we have to-day with the Navy Department. [Applause.] It is a pleasure to every one of us to go there. We feel that we are not only doing what we should in helping the Navy, but we feel that what we are endeavoring to do is being appreciated. [Applause.]

There is a good deal more in this, gentlemen, than appears on the surface. When the famous remark about a treaty being a scrap of paper was made, there was a great deal more truth than poetry in what was said. No lawyer who ever lived can draw a contract that is binding on two parties who do not have the spirit of living up to it, and the most vital thing in all business is the desire of both parties to make the contract a living instrument, and to my mind, more than any other one thing, the thing that is going to carry us on to what I believe will be the successful accomplishment of this stupendous job that has been undertaken

for the Navy, is that we feel that we have been given every opportunity—we feel that, aside from the labor question, of which I will say more later, that the responsibility has been put on us, and that if we do not get the results there are no alibis we can properly urge. [Applause.]

Now, gentlemen, for many years shipbuilding in this country has been a big enough business to be a target, but it has not been a big enough business to be a power. To-day that situation is radically changed. Five men sitting around a table in Washington the other day counted up and found that they employed in the shipbuilding business not less than 50,000 men. Two years ago there were employed in shipbuilding in this country a total of only 70,000, and by the end of the coming year, I should say, there will be upwards of a half million men employed in our business. Is it not strange, gentlemen, that at this time, when shipping and shipbuilding occupies the place in the public eye that it does, that we have no representative on any one of the great committees in Washington that are steering the destinies of this nation? [Great applause.] There are half a dozen men whose names will occur to any one of you who have the experience, the breadth of vision and the ability to measure up to the best standards that have been set for the men on the Council of National Defense, and yet we are without a representative on that council or any similar body, and I believe that one thing that should be done before we leave this room this night is to petition the President of the United States to appoint a representative of shipbuilding on one of these important councils or committees, that the voice of the shipbuilder may be heard in high places for the good of these United States. [Applause.]

Gentlemen, the hour is getting late. There is not much that I can say about the Emergency Fleet Corporation. The stupendous undertaking of organizing a business of the size of that corporation must appeal to each and every one of us. The difficulties in getting well-ordered and smoothly operating machinery to carry out its undertakings are enormous, and we must all recognize that no such machine in private life has ever been put into operation without speaking of the cogs.

There are two points, however, that I think are worthy of attention. It has seemed to me rather unfortunate that such large predictions have been made of the probable output of shipbuilding in the coming year. A year ago the output of the shipyards of the United States was some 550,000 gross tons. Last January I predicted that this year would show about 1,250,000 gross tons. Owing to shortages of material and labor difficulties, we will come considerably below that mark. The actual figures are not available, but I should calculate, from the figures at my disposal, that it would be nearer three-quarters of a million than a million and a quarter gross tons. If this industry can turn out 3,000,000 gross tons of shipping next year, besides the enormous program for the Navy, it will be a result that we may all regard with the greatest of pride. It must be remembered that in the next twelve months over three-quarters of the efforts of the older yards, those yards that have had the most experience and that have done the most shipbuilding in the past, are not going to be available for merchant tonnage, and that where these yards

might turn out 1,000,000 tons, if they had no other obligations, if they can contribute 300,000 tons next year they will have done their part, and it is going to be on the newcomers in this difficult field that the enormous burden of this great program will rest. If, gentlemen, we hit the 3,000,000-ton mark, we will have done our bit.

It is rather a mistake to get gross tons and dead-weight tons mixed up. Practically all statistics have been given in gross tons until recently. But recently the dead-weight tonnage has been substituted for the gross ton for American statistical purposes. Under such a system 3,000,000 gross tons becomes 4,500,000 dead-weight tons, but the carrying capacity is the same. When we hear of ships being sunk we do not read of dead-weight tons, but of gross tons that we in turn must replace, and it is carrying capacity in cubic feet that we need, to feed our armies and our allies on the other side of the ocean rather than the dead-weight capacity so often referred to. [Applause.]

One other point. Just recently there has been appointed by the Atlantic Coast Shipbuilding Association, an association of some eighteen shipbuilders along the Atlantic coast, a committee of five men to consult with the Emergency Fleet Corporation with reference to matters of vital importance. It seems to me that if this committee acts wisely, and if it is, as I believe it will be, received by the Emergency Fleet Corporation, that it may be an extremely valuable vehicle for smoothing out many misunderstandings, and for building up between the corporation and the shipbuilders the same cordial feeling and the same hearty sympathy that exists to-day between the shipyards and the Navy, and there is no more important work ahead for this body than to build up between these two elements, that are so necessary in carrying out our program to a successful conclusion, the cordial relations which should exist between them. [Applause.]

Now, gentlemen, I come to the most dangerous part of my subject. The performance for the next twelve months is going to be the performance of labor. I believe in the American workman. I like the American workman. I personally see a good bit of him. I like to have the men come into my office, and they know I like to talk to them—like the Secretary, I have given up a good many hours I might have had to myself, to talk to some workman who had something on his mind. If you can talk to them individually, or if you can talk to them in small bodies, they are usually reasonable, but in larger bodies they are not so reasonable and they are often led very badly astray. I personally believe from my own observations, and from what I have heard from people more closely associated with these gentlemen in Washington, that the big labor leaders in Washington to-day are actuated by the same desire to win this war that is in the breasts of those of us who are here to-night, but there are other men, who are further down the line, who do not always stand in the same relation to this matter.

We had a recent instance at Quincy, where twelve hundred men walked out of our shop without ever talking to any member of the company. Their grievance, I believe, was a fancied one. If it was a real one it was one which could have been easily and rapidly adjusted, but we lost one working week before they accepted the arbitration we would

have given them without their ever leaving the shop, and that week is gone, never to return.

At the present time there are in Boston three strikes that have been called with a view of forcing a contractor who has always run open shop in the Boston district to accept the closed shop principle. That contractor is not an open shop contractor. He is doing to-day in Buffalo a very large job where he is running a closed shop, but he has found from his experience in Boston that to get his work done there, under the conditions that exist, he cannot deal with the local union officials as they stand. These same union local officials were ordered on Tuesday last to put their men back to work on these three vital government jobs, and up to this afternoon they had absolutely refused to do so. Now it is situations of that sort that have given me the very deepest concern. These things will gradually cure themselves, I believe, but we cannot wait for that time to come, and I believe that the biggest thing ahead of this country to-day is the conceiving and the carrying out of a campaign of education among the men who are employed in the shipyards and munitions factories of this country. If Vance McCormick could head such a campaign, a campaign conceived in a way that no political campaign was ever conceived; if men like Underwood, Taft, Roosevelt, Champ Clark and hundreds of others of the very great leaders of this country could be put out among the workmen to teach them that this is their war, and that there is no excuse under the sun for stopping one day of labor, I believe the result of that campaign would be the most glorious success of anything we have yet undertaken. [Applause.]

There is a force, gentlemen, that will be gradually more and more felt, the force of the mother love, and of the fathers and of the brothers and the sisters of the men in the trenches. One of our blacksmiths said to me the other day, "Mr. Powell, I have four sons in the trenches in France. Do you think I will strike?" But, gentlemen, we cannot wait for that time. What we need is something to put into the workman the knowledge of what it means for this country to lose the war. Gentlemen, if this cannot be accomplished, these vessels upon which we are working to-day will still be built, but they will be built by the American workmen for the German Kaiser and not for our great country, these United States of America. [Applause.]

This situation is serious beyond words. It is one we must face, that we must meet, and meet aright. This problem is not bigger than the American people, because the hearts of these men are all right, but it is a question of getting these facts home to them and letting them see that to lose this war with two million or more of American troops on foreign soil would mean the extraction from this country of the last penny, the practical extinction of our industries, and the practical effacement of this country from off the face of the earth. Is anything too big to risk to prevent such a possibility? If labor is not in this war, we cannot win it and if, as I believe, we can get them in it, whole-heartedly, as surely as the sun rises to-morrow, victory will sooner or later rest on these American arms. [Applause.]

I have very little more to say. I hope from my remarks that some practical results may follow. Nothing that I have said has been intended as critical. Criticism is one of the easiest things in the world to invoke, because in times like these the only man who can

be free from criticism is the man who does nothing. We are all working more hours a day than is good for us, we are traveling more miles than is comfortable, and we are spending more of our own money and of our profits than looks pleasant, but Dr. Elliot in a short speech the other night at the close of a meeting of the Economic Club in Boston summariized the whole situation in a few brief words. He said:—"Don't talk to me of the sacrifice of labor, don't talk to me of the sacrifice of capital, don't talk to me of the sacrifice of you men around this table in time and effort; the only sacrifice that is worthy of mention to-day is the sacrifice of the men who are offering their lives for the freedom of this country." [Great applause.]

And so, gentlemen, if we can take away from this room to-night the thought that there are three constructive things that can be done—the appointment of a representative shipbuilder upon the Council of National Defense; the insuring of the relations that we want to exist between the shipbuilder and the Emergency Fleet Corporation, and the undertaking of a campaign of education among the workmen of this country, believe me, I would feel that the time I have spent here to-night has been repaid a millionfold. [Great applause.]

The Toastmaster:—Gentlemen, we are nearly to the end of the speaking program, but I want to tell you at the close of the next speech there will be exhibited to you some moving pictures loaned to us by the British Commission, by the Italian Commission and by our own Navy Department, and I am sure you will all be very much interested in them.

First, I want your consent that Mr. Powell shall prepare the resolution he spoke of in regard to the appointment of a shipbuilder on the Council of National Defense. Those in favor say "Aye"; contrary-minded, "No." It is carried unanimously.

I know it is getting late, but I also know you will be well repaid by staying a little while longer. In one of the public schools there was a history lesson recently, and in the review of the history lesson the teacher said:—

"Tommy Powers, who discovered America?"

The little fellow turned white, looked around at his classmates on both sides, and hesitated.

"What is the matter, Tom; don't you know who discovered America?"

"Oh," he said, "please, teacher, don't ask me that question."

"Why, what is the matter?"

"You see, we were talking about that yesterday, and Paddy Flynn said it was an Irish Saint, and Olaf said it was a Norwegian, and Gustav said it was a Swede, and Tony said it was Columbus, and if you saw what happened, you would not ask a little fellow that question if he did not have the gang with him."

America has discovered herself on the march up to the gate of destiny, and the next speaker, who happens, by the way, to be a Baptist clergyman, one of those referred to by

the Secretary, of ancestors who came over on the Mayflower, who resided in Massachusetts, was transported to Canada, but who has returned from Canada, a "Man Who Came Back," and who will speak to you on—

"America at the Gate of Destiny."

I introduce to you, with great pleasure, the Rev. Doctor Charles A. Eaton.

ADDRESS OF REV. DR. CHARLES A. EATON.

Mr. President and gentlemen, I will be, like the old preacher, short and brief. When I received the invitation to speak before this great gathering, I could hardly understand the terms in which the invitation was couched. I felt a little like the man running in a local option district in New Jersey, who was approached by one of his constituents with the question, "Do you ever consume any alcoholic stimulants whatever?" He replied, "Sir, before I answer that question, I want to know whether it is addressed to me as an inquiry or an invitation." [Laughter.]

I have come here to-night in response to the invitation and the inquiry, as an American citizen, not because I have anything, perhaps, to say to you men that will be beyond what you already know and appreciate, but just to stir up the fire a little. You remember there was a time when the women in this country wanted to look as much like the men as possible. They have gotten over that, since so many have the vote, but in those days they wore men's hats and men's boots and men's other articles—well, they have been doing that always—and at last they put on suspenders on the outside of their clothes. Down south, in a well-conducted negro family, Ephraim and Sue, brother and sister, had a quarrel over Ephraim's suspenders. He came home one night, intending to go to a dance, and found his sister had taken his best pair of suspenders.

He said next morning, "Susie, did you take my best suspenders last night?"

"Yes."

"What did you do that for? Didn't you know I wanted to wear those suspenders to a dance?"

"Yes, but I did it to keep the fashions up."

"Susie, I want you to understand dat dem suspenders were intended to keep up something far more important than the fashions." [Laughter.]

I am here to speak, not simply as an after-dinner speaker, but to speak as a man dedicated to the task of strengthening the good principles in human life. That is a great task. As I looked over this company, I realized the vital place you occupy in the making of this momentous history unfolding before our eyes to-day. I have a hundred years of shipbuilding stock in my blood—my father went broke building ships, and I have been poor ever since. For this reason I know a good deal about the shipbuilding business that you men do not know, judging by your appearance. Nevertheless, I feel that here to-night in this company are the men who, perhaps more than any other single group in this nation, have in their hands the destinies of this country. But I say that you men cannot meet that great and high opportunity, and discharge the task and burden which has been placed upon you,

unless you are something more than shipbuilders, unless you are Americans—yea, something more than Americans—unless you are great enough in mind and soul to associate yourselves in thought and feeling with this greatest of all issues that has ever confronted the sons of men.

In August, 1914, there emerged out of the silence and security of a world-wide peace that greatest of all nations, from a technical point of view, the Germans, and they struck one shattering blow at the accomplished institutions of mankind. At that blow those institutions which we had all believed were permanent and eternal crumbled into irremediable ruin, never to rise again. If it had not been—and it is always good for us to realize this—if it had not been that there were brave men in Belgium and brave women, and brave men in France and brave women, and brave men in Britain and brave women—if it had not been that out of the British ports there stole that grey line of battle ships that took their place in the North Sea and have held their place there ever since, you and I would not be here to-night talking about building ships. [Great applause.]

The world was asleep. The world was fat and prosperous, self-satisfied, and its soul was dying or dead, and Germany, with that shattering, crushing blow, has been the world's savior. I believe she has added five hundred years to the life of the British Empire. [Applause.] Germany, by her barbaric actions, has welded more strongly that vast and mighty empire. When she put the trumpet to her lips and blew the blast of the world's doom, instead of seeing the men who speak English fall upon their faces, she summoned from Australia and Africa and India and the islands of the sea the far-scattered sons of old Britain to her defense, and they have laid their lives by the millions upon the altar of their country, in defense of its freedom. [Great applause.]

I was in Toronto addressing a great company of men the other night. They were just as fine looking men as you are, and before I spoke I witnessed something that has been impressed upon my soul with a thrill and a sorrow that I can never outlive. The chairman rose and said, "Gentlemen, I ask you to stand and drink a silent toast to our sons who have fallen." And these men stood, and a great sob came welling out of the depths of that silence. They told me afterward that over one hundred men in that room had lost a son at the front, and some of them had every son in their family, in some cases two or three, buried in the soil of Flanders. The war meant something to those men, and a year from now it will probably mean much more to you and me than it does to-night.

I have come to say a few words to widen out the skyline of your faith and feeling. There are three or four great central realities which have been unveiled in the last three years of this war. First, that democracy is the choicest possession, from a social and political point of view, which the world contains; that now it is on trial, supremely, preparing itself for general adoption by the whole family of nations, and unless it can endure this trial it is doomed to fail as a method of self-government and a method of efficiently carrying on the business of life. Secondly, there is the merging into the consciousness of men a new concept of the reality of life. We have discovered that the nation is something more than

acres of land and infinite millions of money heaped up in banks and in business. The nation is a soul, and the man is a soul, and nothing else is the nation, and nothing else is the man. The reason that Germany is a world menace to-day, and must at any cost be beaten to the death, is that her soul has gone rotten within her. [Great applause.]

Four hundred years ago Germany saved the world. Four hundred years ago the German lighted his torch at the altar of his Lord, and kindled with that torch every forward movement in the civilized world. Out of the loins of that Germany of four hundred years ago there leaped those tremendous forward movements and the concept which resulted in this nation and in all of the other free institutions and governments of our age. To-day the descendants of that age in Germany are pledged to the hellish task of destroying the light that has lighted the world for four centuries. We must beat them—we must beat them to the dust. We must save their souls, or, by the gods, we shall lose our own—there is no doubt about that. We have many Germans in this country, and they are in a horrible situation. But this is what I say to the Germans in America—I do not mean now German-Americans, there is no such thing as a German-American. [Loud applause.] This is my creed—there is only one kind of an American; if you have a German-American, or a French-American, or a British-American, you have not an American at all; he has got to be an American and nothing else. [Loud applause.]

This is what I say to the Germans, not those people of German ancestry who are Americans—they are Americans the same as the rest of us—but to the Germans in this country:—In 1776 this nation was an Englishman's nation, but under the direction of a lunatic German king, the Englishmen of England undertook to ram down the throats of the Englishmen in America principles and doctrines which were contrary to the traditions of our race. The English king could not get Englishmen to fight Englishmen for him then. He had to hire Germans even then to do it. We did what the British have thanked us for ever since, licked them to a standstill, and that is what we are going to do now to the Germans if the old spirit which made our ancestors so great has not died out of us.

I say, then, to the Germans in this country, you have got to do to-day what the English-Americans did in 1776—fight your own people. You must fight men of your own breed and blood until they come to their senses. That is not an easy thing, but this is an age of heroism, and we must rise until we are greater than any of the limitations that surround us, and we must act in a consciousness of the best interests of the world and of our own nation and our own souls. The soul is the man. The soul is the nation. Oh, when those millions came here in '48, fleeing from the tyrannies of Europe, they brought, no matter what their ancestry may have been, something to our souls. They saw the star in the sky. They heard the voice wooing them across the sea. They came here with their spirits aflame with a passion for freedom, and with high ideals, and we received them into our lives. What men they made. What citizens grew out of those German immigrants of 1848!

But in the last generation or two we have had millions upon millions of men come into this country for economic motives, and nothing else. They came here because the trough

was bigger, and there was more swill in it than there was at home. They got in with all four feet, and instead of our lifting their souls up by the influence of our souls, and telling them that America was not a trough, but a soul, we were just as bad as they were. We, too, were getting fat and making material progress, and we did not tell them about the spirit and dreams which in the early heroic days made our nation so great and glorious, and we did not wake up until a few years ago when we discovered that we had a nation divided against itself.

When our President asked us to be neutral, and seemed to be stepping so softly, in the first part of the war, all of my Yankee blood boiled. I wanted him to get out and get busy and join in, and get it over with, but I see now that I was wrong and he was right, because he knew he could not carry America with him, because we had scattered throughout the length and breadth of our country millions of people of strength and position who were, it is true, in sympathy with America, and yet they were also in sympathy with Germany, and he had to wait until he could carry at least a majority of the nation with him. He has that majority now and that majority is growing every day, and I believe the time is not far distant when we shall call from their hiding places these vipers of assassination and vicious propaganda who have bedeviled us too long, and punish them as they should be punished, and then we shall have a solid, substantial American citizenship, no matter what our ancestry or breed may have been. [Applause.]

In the third place, this war has brought to our consciousness and our understanding as never before, the fact that liberty is the most priceless thing in the world, but that it is worth all it costs. We used to think a few years ago that liberty just happened, that we were born that way, and that everybody in the world was born that way, and nobody had to buy or pay for this priceless thing. We have discovered now that liberty is not an opportunity for self-indulgence, but liberty, rather, is a discipline, a burden, a task, a high challenge to the spirit of man, and no man dares now to call himself free unless he is prepared to fight, and to sacrifice, and if need be, to die, for the thing that he calls liberty. [Great applause.]

I was down in Madison Square Garden yesterday and saw a crowd of over one thousand listening to a wonderfully brilliant young Russian Jew, and I approached to hear what he had to say. To my astonishment that young gentleman was making a speech to that silent throng of men at high noon in the heart of New York on the wrongs of the Hebrews in America! To outer darkness with him, I say, and all like him! [Great applause.] The day is coming, and coming soon, when that style of oratory will have to be hushed in this country. They took a man the other day going aboard a ship, one of our transports, who had a bomb in his pocket 18 inches long and 3 inches in diameter, which contained enough high explosive to rip a ship open on the high seas and destroy the lives of thousands of our young men. I do not know where he is, but he is probably being fed on chicken in some of our nice jails and being treated like a Christian. The day must come soon when, in the interests of our humanity, and in the interests of our country, and in the interest of the great conflict in which we are engaged, if we find in our midst a man like that we will take him out in an

open lot and start the time clock on his bomb, and stand around until it goes off, and he goes with it. [Applause.] You cannot have liberty in this nation when you permit millions of your fellow-citizens to indulge in such license and to assassinate the very nation that your boys are preparing to give their lives for. You have got to have honor and manhood, and sternness and force in your Government and in your public opinion to bring these men to book and bring them soon.

Let me say this, as I close:—First, America in this war is fighting for the very principles upon which she is founded, and I believe that this great fire burning in your bosoms to-night is spreading, spreading to the east and west, the north and south, and it shall spread until we shall see a solidarity of opinion and a oneness of moral reaction, and a rigidity and fixedness of purpose which will make the hundred millions of our population all unite with our allies to answer the shattering blow of Germany with a blow more shattering and more disastrous than any Germany ever dreamed of as being possible. I believe that.

But, gentlemen, there are a few things we must do of a practical kind. First, we have got to meet the German propaganda in our midst with another propaganda. Our friend, the brilliant young shipbuilder who has just preceded me, gave you a very solemn message when he advised a campaign of education among our people to enlighten them on the principles at stake in this war. I say that the strongest and best men and women in this country who see this thing in all its outline and meaning, who see the relation of this country to this great war, are under obligation to enlist with every facility at their command to teach the masses of our people the great principles of Americanism. We have not instructed our masses, we have not instructed our foreigners, we have not instructed our home-born, the ordinary everyday citizen, in the great ideals and principles of our national institutions, and we must do it now, like we have to build ships, in a hurry. It is too bad that this is the fact, but it *is* the fact, and it is therefore the duty of every man, everywhere, to continuously present to all whom he meets the great principles of Americanism, until the whole nation shall become aroused to these principles and shall beat down, with horror and disdain, an abominable propaganda which is going on in our midst, so subtly and continuously everywhere. And last and most important of all, gentlemen, there is only one word in your vocabulary and mine now, and that is the beautiful and ancient work of sacrifice.

This is what I have to say—our boys, like those British and French boys, and Belgian lads, those Canadians, those Australians, those Italians, and all the others—our lads are risking on one throw everything they have. A man can give no more than his life. That is all he has to give. A man who enlists may come back without a splinter or a scratch, but he gambles on that, he puts the stakes down on the table and says, "There is my life." I stand before every one of these men with a reverence and an affection too deep for words. I could not look them in the face if, while they are doing that, I was side-stepping my share of the burden and the responsibility. I say, gentlemen, that for men to try to get rich until after this war is over is treason against humanity, and I say to the laboring men of this country that somehow or other you have got to emerge from the gloom and shadow into

which you have been led by false prophets, until you and the men who have money stand shoulder to shoulder, until that cursed of all delusions, class consciousness, is obliterated and swallowed up in the larger consciousness of one humanity, and one Kingdom of God, and one great sacrifice like the sacrifice of our Blessed Redeemer upon the Cross. And when we reach that point no brutality, however massive and efficient, no subtlety of detraction and propaganda, however widespread, and no far-flung battle line, or line of ships, can win the war against a humanity marshalled in a sacrificial spirit that will keep nothing back in order to save the world.

To this work, then, gentlemen, you and I and every other man and woman in the United States are summoned, without reservation, until this war is won. [Great applause.]

The motion picture slides were shown, after which the company dispersed.

Deaths, 1917

WASHINGTON IRVING BABCOCK

VICE-PRESIDENT

On August 7, 1917, Washington Irving Babcock, a prominent and influential member of this Society and one of its vice-presidents, died at his home in New York City.

Mr. Babcock was a son of Captain David S. Babcock and was born in Stonington, Conn., September 28, 1858.

His early life was spent in Brooklyn, where he received his education in the Public Schools; graduating from the Brooklyn Polytechnic Institute in 1876, and from the Rensselaer Polytechnic Institute of Troy, N. Y., in 1878, with the degree of civil engineer.

With such a broad foundation securely laid upon which to build a career, it is evident that his choice of the profession of naval architect and engineer was based upon most excellent judgment, for at the time of his death he was easily ranked among the leaders of his profession.

Entering the employ of the Morgan Iron Works in 1878 he was soon transferred to the shipyard of John Roach & Sons at Chester, Pa., with whom he remained until 1885. The following two years were spent with the Providence & Stonington Steamship Company as assistant superintendent, and in 1887 he accepted the position of superintendent of the Union Dry Dock Company at Buffalo.

Two years later he organized the Chicago Shipbuilding Company and assumed the management of that yard at South Chicago, later becoming president of the company, in which position he remained until its absorption by the American Shipbuilding Company in 1900.

Since that time he had been practicing his profession in New York City, joining in 1907 with Henry Penton, formerly engineering manager of the Chicago Shipbuilding Company, and conducting the business under the firm name of Babcock & Penton, with offices in New York and Cleveland.

His disposition was bold and original, so that, when he had attained a position where he could do so, he introduced or adopted new and improved

methods of design and of construction. He was probably the first shipbuilder to adopt pneumatic tools, thereby setting a standard which has become universal. He likewise introduced the mould system of construction. Both of these improvements have increased the capacity of, and reduced the cost of construction in the yards. He was also one of the first to use the electric drive for propulsion, which he did in two large fire boats for the city of Chicago. The design was ingenious, providing, as it did, that the power of the turbines driving the pumps, which was largely in excess of that required for propulsion, could be applied through direct-connected generators to the propeller motors and thus the same main units were employed for both purposes very successfully. The modern bulk freighter of the Great Lakes owes its longest steps in development to him, the first 400-footers having been built by him at South Chicago.

Mr. Babcock was one of the brightest, broadest and most unselfish men in his profession, a gentleman of the highest character and strictest integrity, and one whose friendship was greatly valued. At the present time, when the United States is engaged in this greatest of world wars and the submarine menace is threatening the very existence of our shipping, his broad experience and knowledge would have been of great assistance to his country.

Mr. Babcock was one of the most active and loyal members of our Society, almost invariably present at meetings of the Council and the Society, in which he always took an active part. He contributed a number of very valuable papers to the transactions and was always ready to enrich the discussion of papers where his experience and judgment would elucidate or elaborate the original paper.

He was a vice-president and member of the Council of this Society, a member of the American Society of Consulting Engineers, a member of the Institute of Naval Architects of Great Britain, a member of the United States Naval Institute, and one of the Board of Management of the Engineers' Club.

FREDERICK HAVILAND CHASE

MEMBER

Frederick Haviland Chase was born on August 17, 1882. He was a graduate of Webb's Academy, and went directly from the academy to the employ of Tams, Lemoine and Crane, first as draughtsman and finally as chief draughtsman.

The vessels designed by the firm in which Mr. Chase took part were, in addition to the Dixie I, Dixie II, Dixie III, and Dixie IV, the motor yacht Tarantula, the sloops Spider and Soya, the schooner yacht Dervish, the auxiliary barque Aloha, the auxiliary schooner Alcyone, the steam yacht Vanadis, the fire boat Fire Fighter, and a number of others.

In addition, the following vessels can be placed almost entirely to his credit:—The sloop yachts Jacktar and Invader, the motor yacht Sabalo, the St. John's Floating Hospital Boat, the Helen C. Juilliard, the motor yachts Albacore and Drusilla, the steam yacht Wenonah, and a number of others of varying sizes and types.

He died on July 8, 1917.

WILLIAM CONANT CHURCH

ASSOCIATE MEMBER

William Conant Church was born in Rochester, N. Y., August 11, 1836, removed in 1848 to Boston, and in 1854 established his residence in New York City, where he resided until his death.

Born in a family largely devoted to literary pursuits, he was at the age of nineteen proprietor of a weekly publication. At twenty-four years of age he was at the head of one of the New York dailies, with a circulation then exceeding sixty thousand, the New York *Daily Sun.* He withdrew from this paper in 1861 and was traveling in Europe at the outbreak of the Civil War. Returning in July, 1861, he attached himself to the joint military and naval expedition under Admiral S. F. Dupont, U. S. N., and Gen. W. T. Sherman, U. S. A., and participated in various incidents of that undertaking. He subsequently joined the Army of the Potomac as a volunteer aide on the staff of the late Gen. Silas Casey, U. S. A., and continued with him during the siege of Yorktown, and through the general's subsequent career on the Peninsula, participating in the battle of Williamsburg and that of Fair Oaks, where he was wounded. General Casey appointed him to a vacancy on his staff with the rank of captain, and subsequently he received the brevets of major and lieutenant-colonel of volunteers.

While he was on the staff of General Casey, the project of an army paper was brought to his attention, and he resigned to undertake the establishment of the *Army and Navy Journal,* with which he was connected until his death.

Colonel Church was well known in literary circles through his "Life of Ulysses S. Grant" and also for his "Life of John Ericsson." He was a man of distinguished ancestry and a member of the most notable military and social organizations of New York. He was a genial, hospitable gentleman, with a wide circle of friends won to his side by his agreeable manner, and whose friendship he retained by his sterling personal qualities and his unselfish devotion to the highest interests of the Army and Navy.

OLIVER ZELL HOWARD

MEMBER

Oliver Zell Howard was born in Raleigh, N. C., on December 6, 1876. He was graduated from Lehigh University with the class of 1896, and during the next year was employed in the shops of the Crawford Manufacturing Company, Hagerstown, Md.

His draughting-room experience he obtained with the Newport News Shipbuilding and Dry Dock Company, where his work dealt with marine-engine and boiler draughting. His next position was with the Baltimore Smelting and Refining Company on general machine draughting. In 1900 he turned again to marine-engine and boiler draughting with the Maryland Steel Company, Sparrows Point, Md. For about a year he was connected with the Bureau of Construction and Repair, Navy Department, Washington, D. C., on auxiliary machinery, resigning to take the position of mechanical engineer with the American Carbide Lamp Company, Philadelphia, Pa. In 1902 he became an instructor in the department of marine engineering and naval construction in the United States Naval Academy, Annapolis, Md. He assisted the head of the department in preparing textbooks on naval engines and machinery and on mechanical processes. He also assisted in the laying out and the superintending of the erection of experimental turbines and boilers in the Naval Experiment Station at Annapolis, and in making tests on the machinery already erected. For the last three years he has been supervising engineer of the Diamond Match Company.

Mr. Howard was a member of the American Society of Civil Engineers, the American Institute of Electrical Engineers and the American Society of Mechanical Engineers. He died on December 20, 1917.

CHARLES EDWARD HYDE

MEMBER

Charles Edward Hyde was born in Bath, Me., November 26, 1855. He attended the public schools of Bath, and, when graduated from the high school there, spent the next three years in the Worcester Polytechnic Institute. The last year of his course was taken in the Massachusetts Institute of Technology. The year after his graduation he spent in Europe for the purpose of examining the shipyards and engine works of the old country, obtaining valuable information in his specialty.

Upon his return he worked as machinist in the Portland Machine Shops, and then as draughtsman in the Columbian Iron Works at Baltimore, Md. He was next employed in the drawing office of Cramp's Shipyard, Philadelphia, Pa., and later was chief draughtsman for Ward, Stanton & Company, Newburg, N. Y., builders of all types of fast vessels. This last position afforded him the advantage of working with Mr. Stanton, who was noted for his ability as a designer of marine engines.

Returning to Bath in 1884, he entered the employ of the Goss Machine Iron Works as chief draughtsman and superintendent, and during his service there he introduced the practical use of the triple-expansion engine, the first to be employed in this country. When this company changed ownership he was employed by the Bath Iron Works, and was chief draughtsman and constructor of the engines of the Castine, Katahdin and Machias.

As a citizen of Bath Mr. Hyde was active in civic affairs. He served in both branches of the City Council and was Mayor in 1899 and 1900.

After leaving Bath he became general manager and president of the New London Marine Iron Works, at New London, Conn. For the last few years he was engaged in business in New York City.

He was a member of the American Society of Mechanical Engineers and of the Engineers' Club of New York. He died May 19, 1917.

JOHN S. HYDE

ASSOCIATE MEMBER

John S. Hyde was born in Bath, Me., March 25, 1867, and died at St. Augustine, Fla., March 17, 1917, at the age of forty-nine years, eleven months and twenty-two days.

He was the eldest son of Gen. Thomas W. Hyde and Anna Hayden Hyde. There were six children, three boys and three girls, and with their parents they formed a very congenial family with an ideal home life.

Mr. Hyde inherited his lovable disposition from both his father and his mother. In addition he inherited from his father the highest principles of honor, a faculty for making friends, a keen business instinct and a natural taste for mechanics. From his mother he inherited a fondness for reading, great diplomacy, marked consideration for others, and the fondness for music that was possessed by all her family. The most prominent exponent of this talent is her sister's daughter, Madam Emma Eames.

These various inherited qualities were developed by Mr. Hyde and had much to do with his most honorable and successful career.

He spent his childhood and early youth in Bath, after which he attended the Massachusetts Institute of Technology in Boston. Returning to Bath, he learned the business of engine building intimately by serving in his father's foundry and machine shop. Later, after his father had purchased and was operating the Bath Iron Works, he continued his practical education by serving in various branches of the plant and finally became superintendent of engineering.

During this period he spent some time in Glasgow under the instruction of Prof. J. H. Biles, who was professor of naval architecture at Glasgow University.

General Hyde, owing to ill health, resigned active management of the Bath Iron Works, Limited, in 1899, and his second son, Edward W. Hyde, became president of the company, with John S. Hyde as vice-president and superintendent of engineering.

Gen. Thomas W. Hyde died in 1899, and the business, of which he was sole owner, was conducted for the heirs by these two sons until 1902, when the Bath Iron Works and the Hyde Windlass Company, also owned by General Hyde's heirs, were sold to the United States Shipbuilding Company.

Messrs. Edward W. Hyde and John S. Hyde were retained under the new owners in their capacities of president and vice-president respectively. Mr. John S. Hyde in addition held the office of general manager.

In 1905, upon the dissolution of the United States Shipbuilding Company, Mr. John S. Hyde bought the Bath Iron Works, Limited, and operated it as sole owner until his untimely death.

Mr. Hyde's name and fame are largely connected with the Bath Iron Works, Limited. Upon his purchase of the plant, he decided upon the policy of confining its production as much as possible to the construction of very fast vessels of the highest quality of workmanship. This is a class of vessel in which he always took a special interest and also is one for the construction of which his plant was peculiarly adapted in every way.

An alliance with Messrs. August Normand & Company, the great French torpedo-boat builders of Havre, France, which was entered into by his father in 1896, was still in force, and to further strengthen and complete his design facilities for the class of work selected, a similar alliance was made with the Parsons Marine Steam Turbine Company of England in 1905. Subsequent years proved the wisdom of Mr. Hyde's policy.

Among the vessels produced were the scout cruiser Chester and fourteen of the finest destroyers for the United States Navy, two fine passenger steamers for the Maine Central Railroad Company and two very fast turbine-driven steam yachts of large size. These vessels reflected great credit upon the Bath Iron Works, Limited, and Mr. Hyde. The works were also exceedingly prosperous financially during this period, but he took far more satisfaction from the quality and reputation of his product than from the money that it made for him.

In 1913 Mr. Hyde purchased the estate formerly owned by his father and occupied by him as a home until his death in 1899. This estate consisted of a magnificent tract of hilly woodland nearly a square mile in area, situated on the southwest border of the city of Bath. During the years 1913 to 1915 inclusive, he constructed a concrete mansion on the top of one of the hills of this estate, overlooking the Kennebec River, and built many beautiful roads through the wooded portions. A large farm was cleared on the western portion of this land and equipped with fine barns, stables, and dairy. Many blooded horses and cattle were purchased for this farm. Mr. Hyde took great pride in this home and, when he was required to travel for his health during the latter part of his life, his constant longing was to return to the home that he loved so much and also to resume active management of the Bath Iron Works.

Mr. Hyde did not have an enemy in the world; everyone who met him became his friend for life.

Naturally, such a man had many honors bestowed upon him. He was Mayor of Bath, represented Sagadahoc County in both branches of the State

Legislature, and was offered the Republican nomination for Governor. He was obliged to decline this latter honor on account of the demands of his business upon his time. He was a Director of the Maine Central Railroad and an Overseer of Bowdoin College. He was a member of the Colonial Club, Sagadahoc Club, and Sons of Veterans of Bath; the Cumberland Club of Portland; the Metropolitan, Engineers', and Union League Clubs of New York, and the Metropolitan and Army and Navy Clubs of Washington. He belonged to the Loyal Legion of the United States, the British Institution of Naval Architects, the American Society of Naval Engineers and The Society of Naval Architects and Marine Engineers.

Through his consideration for others and his rare faculty for winning and holding the loyalty of his subordinates, he was able to obtain their hearty cooperation in business, and they in turn took pleasure in devoting their best efforts to his interests, which he made them realize were also their own.

Mr. Hyde is survived by a son through a former marriage, John Holmes Hyde, and by his widow, Ernestine S. Hyde. He also leaves two brothers, Edward W. Hyde and Arthur S. Hyde, and a sister, Mrs. John C. Phillips. He leaves a memory in the affections of his friends and the community that will live as long as they do.

WILLIAM D. KEARFOTT

MEMBER

William D. Kearfott was born on January 12, 1864. He began work with the T. Morton Poole Company of Wilmington, Del. Later he was associated with such well-known manufacturers as the International Navigation Company, the Worthington Steam Pump Company, the Geo. F. Blake Manufacturing Company, and the Warren Steam Pump Company. In 1916 he organized the Kearfott Engineering Company.

Mr. Kearfott was an entomological authority of international reputation, his particular specialty being micro-lepidoptera, and he had written considerably on his subject.

Besides being a member of this Society, Mr. Kearfott was a member of several Montclair clubs and the Machinery Club.

He died on November 13, 1917.

PRENTISS LINGAN

JUNIOR MEMBER

Prentiss Lingan was born in Brooklyn, N. Y., August 23, 1891. He afterwards moved to South Norwalk, Conn. After a brief course in Stevens Institute, preparatory department, he entered Webb's Academy of Naval Architecture and Marine Engineering in September, 1910, and graduated therefrom with honor in June, 1914. He did excellent work there and was very popular among the students and highly esteemed by the faculty because of his manliness and high moral character.

Shortly after his graduation he entered the employ of the Lake Torpedo Boat Company, Bridgeport, Conn., where he remained for nearly three years. He then accepted a position with the Perlman Rim Company, Jackson, Mich., where he was at the time of his death, September 25, 1917, resulting from an automobile accident. He was buried in the family plot at South Norwalk, Conn.

JAMES R. RAYMOND

ASSOCIATE MEMBER

Captain James Richardson Raymond was born in Washington, D. C., on September 3, 1845.

He received his education in Washington, D. C., schools and finished same in Georgetown College, D. C. He served in the United States Army during the War of the Rebellion, later becoming actively engaged in seafaring matters, and he was well known in the shipping world, particularly on account of his active interest in the matter of life-saving at sea, which led up to his inventing and patenting the Raymond releasing device for lifeboats.

Captain Raymond died at his home in West Nutley, N. J., on Sunday, May 20, 1917. He left a widow and three minor sons.

GEORGE E. WEED

VICE-PRESIDENT

In the death of Mr. George E. Weed, vice-president of the Society, on April 7, 1917, there was the loss of one of its oldest and most loyal members. He had the honor of being one of those whose names appear in the Charter of the Society, dated April 28, 1893. He was a member of the Council from the early days of the Society, and had been vice-president since 1910.

Mr. Weed was born at Danbury, Conn., on October 3, 1839, and so was nearly seventy-eight years old at the time of his death. Practically all of his active business career had been spent in connection with the Morgan Iron Works of New York City, of which, during the active management of Mr. John Roach, he was vice-president. After Mr. Roach's death and the reorganization of the company, Mr. Weed was president until he retired from active business.

His mature experience went back to the time of the Civil War, for in 1861 he enlisted in the 12th Regiment, N. Y. S. N. G., for the national service. He had an intimate acquaintance with all the older leaders of the profession, and it was extremely interesting to hear him tell of his experiences of those days more than half a century ago. He had kept up his close touch with the men who had come to the front in later years, so that it might be said that he was personally acquainted with all the leading men connected with the marine profession for three-quarters of a century.

Mr. Weed was not himself trained as an engineer, but he was a most capable executive and business man, so that his long connection with one of the leading engineering firms in the country made him a most useful adviser in engineering matters. His opinion was valued most highly by his associates of the Council of this Society, whose meetings he always attended.

Mr. Weed was interested in shipping and other enterprises, and was, for a time, vice-president of the New York & Cuba Mail Steamship Company. He had been for many years a trustee of the Central Presbyterian Church and a trustee of Webb's Academy and Home for Shipbuilders.

When a man's life work is over, and the duty falls to some friend to write a brief sketch like this, the feeling is very strong that, after all, what counts most is the man himself, his personality, and the regard in which he was held by his fellows. In this respect Mr. Weed was singularly happy. Those who knew him best loved and admired him most.

He was, for more than fifteen years, treasurer of the Engineers' Club, where his great business acumen enabled him to render most important and valued service.

On the occasion of his seventy-fifth birthday the members of the club gave him a testimonial banquet, at which was presented to him a golden loving cup. More than a thousand of the members (all who could be reached) joined in this striking evidence of their affection and appreciation. The club had previously ordered a portrait from life, which was finished several years before his death.

It is given to very few to play such a part in the world's work as will cause their memory to live indefinitely, and the making of such records is not always accompanied by the greatest happiness. Our dear friend had a happy life, a highly honorable career, and the affection of a host of friends, and his memory will be tenderly cherished as long as anyone remains who had the privilege of his personal friendship.

GEORGE ANDREW WHITE

ASSOCIATE MEMBER

Captain George Andrew White was born in Shelbourne Harbor, Vermont, in 1856, and was the son of Captain Lavater S. White, who designed and built the famous fleet of side-wheelers for the Champlain Transportation Company and Lake George Steamboat Company.

Captain George White was graduated from the University of Vermont, class of 1877, with a degree of civil engineer.

He was for several years employed by the Champlain Transportation Company, coming to the Hudson River in the early eighties and employed by the Hudson River Day Line, with which company he was associated until his death.

His early training with his father, his engineering work in college, and subsequent work with the Day Line, furnished a most unusual combination of experience and particularly fitted him for his work in working out many of the practical points, especially those leading towards ease of operation and economy in upkeep in the designing of the Hendrick Hudson, Robert Fulton, and Washington Irving.

Perhaps the most remarkable feat accomplished was in the construction of the Robert Fulton, where Captain White, as assistant General Manager and Company representative on the job, was called upon to make many decisions in connection with the joiner work and decoration during the progress of the work. He was thus largely instrumental in enabling the work to be so rushed that the Robert Fulton was running under her own steam 115 days after the keel was laid.

Captain White died suddenly in Asheville, N. C., on March 8, 1917.

To illustrate paper on "The Effect of Wind and Fouling Resistances on the U. S. S. Neptune," by William W. Smith, Esq., Member.

Courtesy Naval Constructor Wm. McEntee, U. S. N.

FIG. 1.—BOW VIEW OF MODEL OF NEPTUNE SUSPENDED IN WIND TUNNEL, WASHINGTON NAVY YARD.

To illustrate paper on "The Effect of Wind and Fouling Resistances on the U. S. S. Neptune," by William W. Smith, Esq., Member.

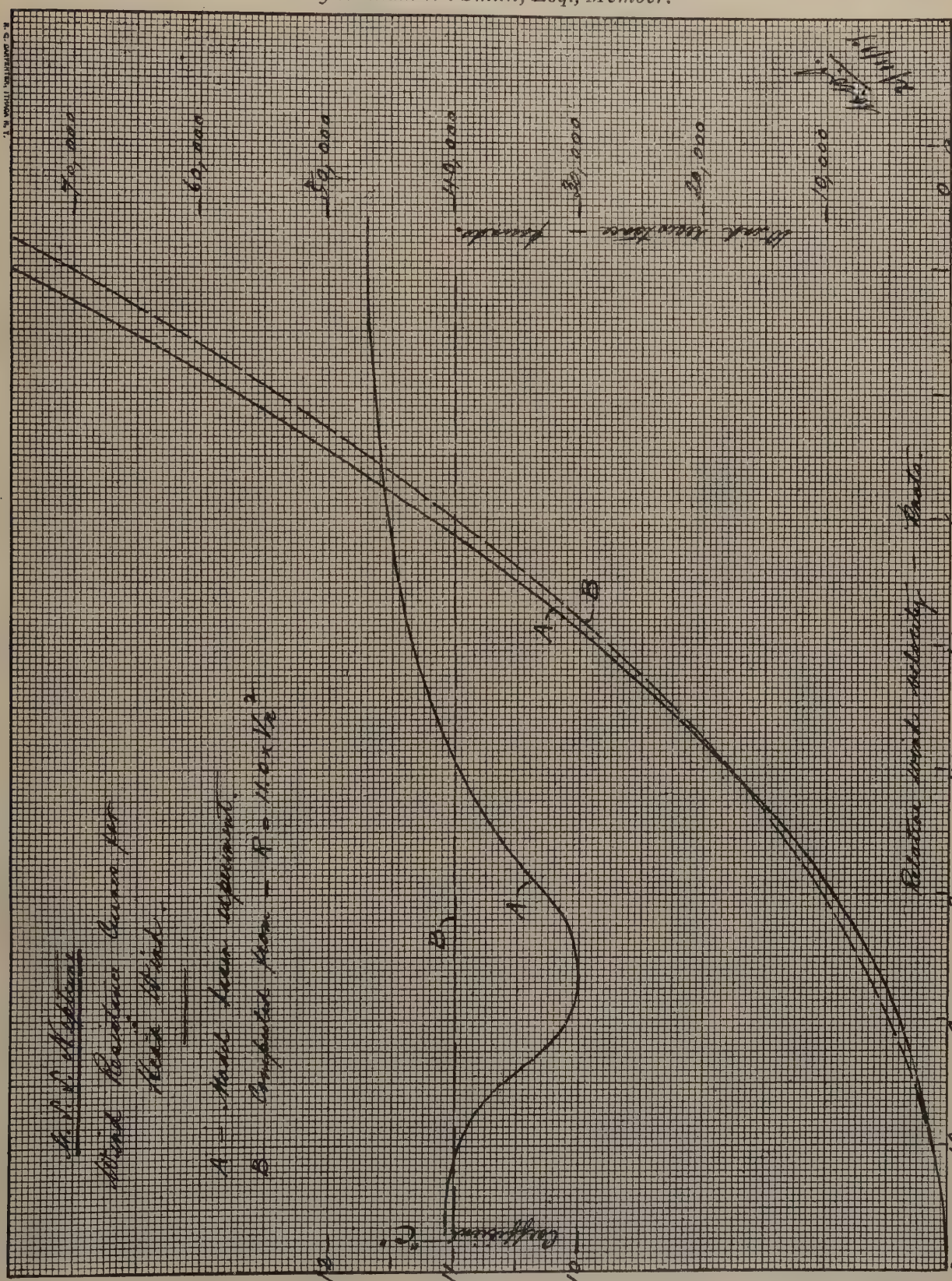


FIG. 3. -- Curves of Wind Resistance and Coefficient C for the U. S. S. Neptune as Determined by Model Experiment, and a Curve of Resistance with a Constant Value of C.

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "The Effect of Wind and Fouling Resistances on the U. S. S. Neptune," by William W. Smith, Esq., Member.

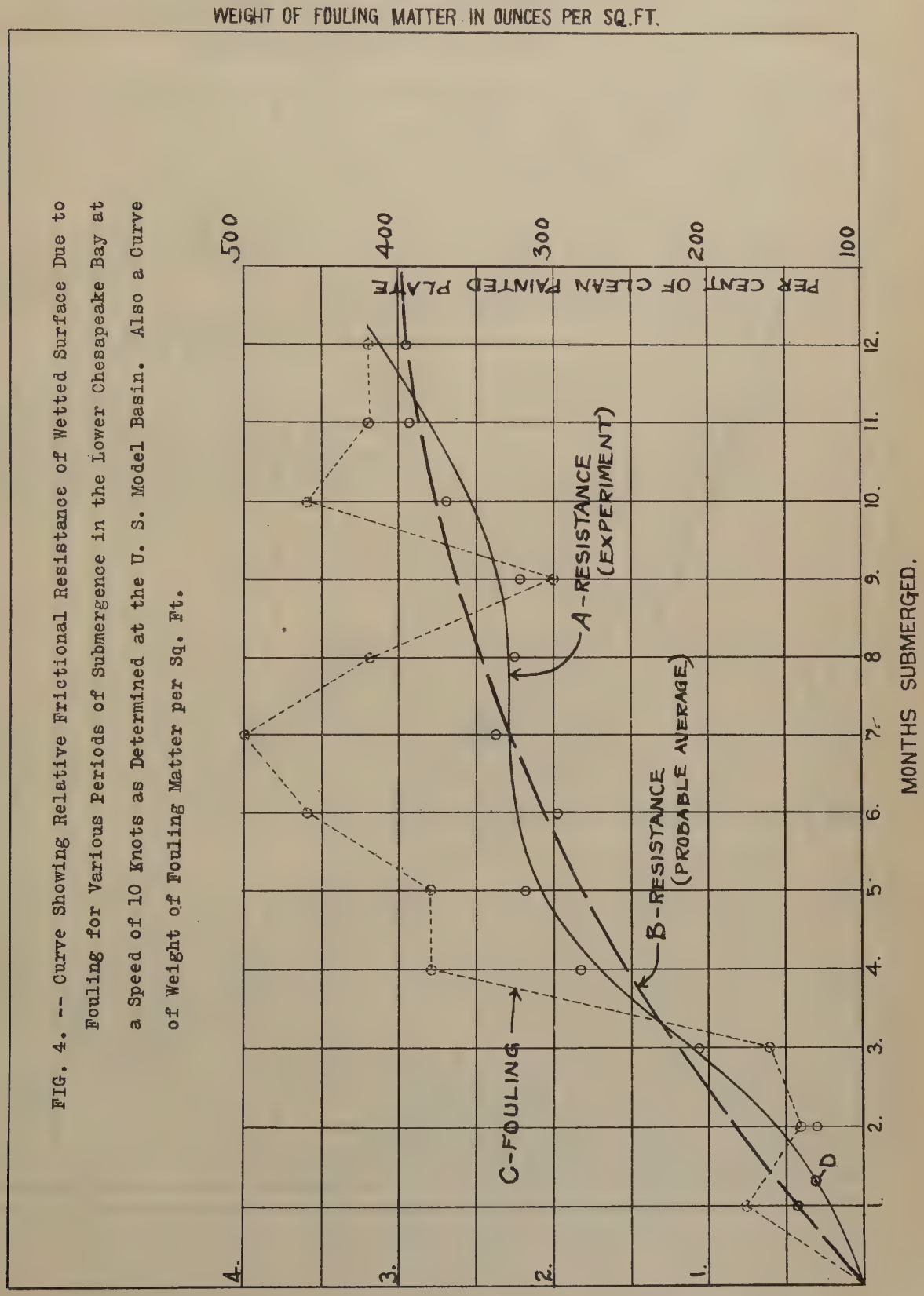


FIG. 4. -- Curve Showing Relative Frictional Resistance of Wetted Surface Due to Fouling for Various Periods of Submergence in the Lower Chesapeake Bay at a Speed of 10 Knots as Determined at the U. S. Model Basin. Also a Curve of Weight of Fouling Matter per Sq. Ft.

THE NORRIS PETERS CO., WASHINGTON, D. C

To illustrate paper on "The Effect of Wind and Fouling Resistances on the U. S. S. Neptune," by William W. Smith, Esq., Member.

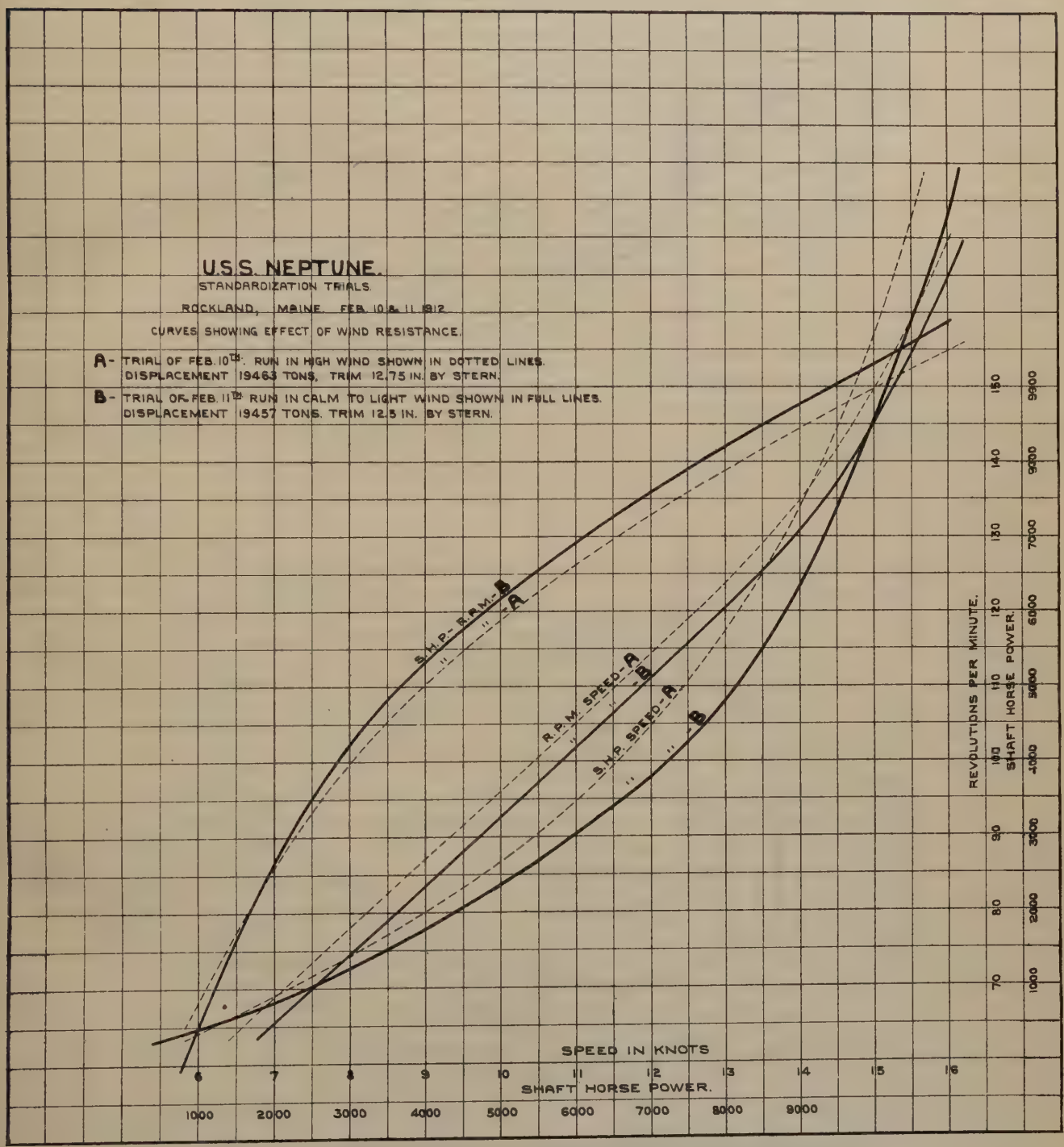
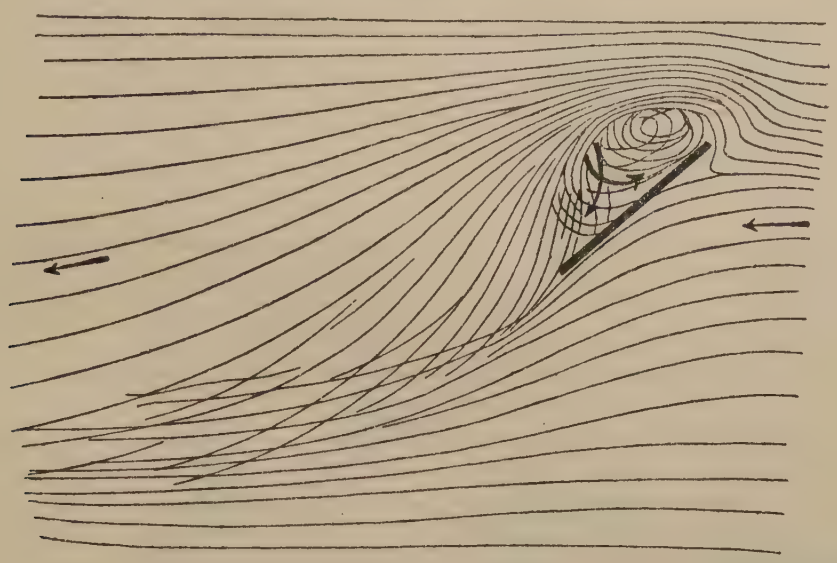


FIG. 5. -- Standardization Curves for Neptune Showing Effect of Wind Resistance during Trials of FEB. 10 and 11, 1912.

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "The Effect of Wind and Fouling Resistances on the U. S. S. Neptune," by William W. Smith, Esq., Member.



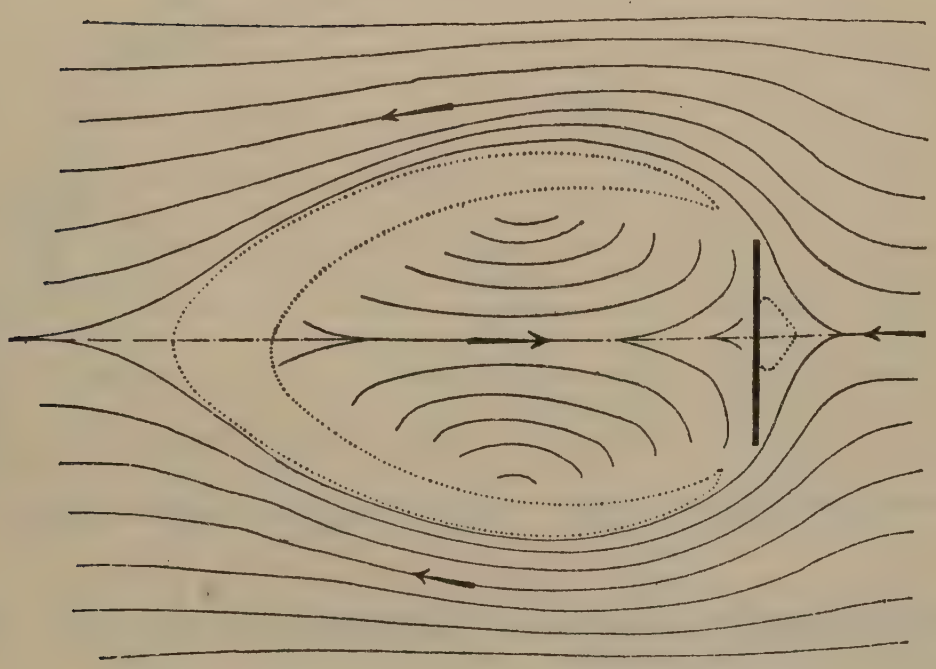


FIG. 6. -- Diagram Showing the Conditions Surrounding Flat Plates Exposed to the Direct Impact of a Uniform Current of Air, for Normal and Inclined Positions.

G. Eiffel.

Courtesy Houghton & Mifflin Co.

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "The Effect of Wind and Fouling Resistances on the U. S. S. Neptune," by William W. Smith, Esq., Member.

Plate 25 × 25	aspect ratio	1		Plate 90 × 15	aspect ratio	6
„ 22·5 × 15	„	1·5		„ 90 × 10	„	9
„ 30 × 15	„	2		„ 15 × 45	„	$\frac{1}{3}$
„ 45 × 15	„	3		„ 15 × 90	„	$\frac{1}{6}$

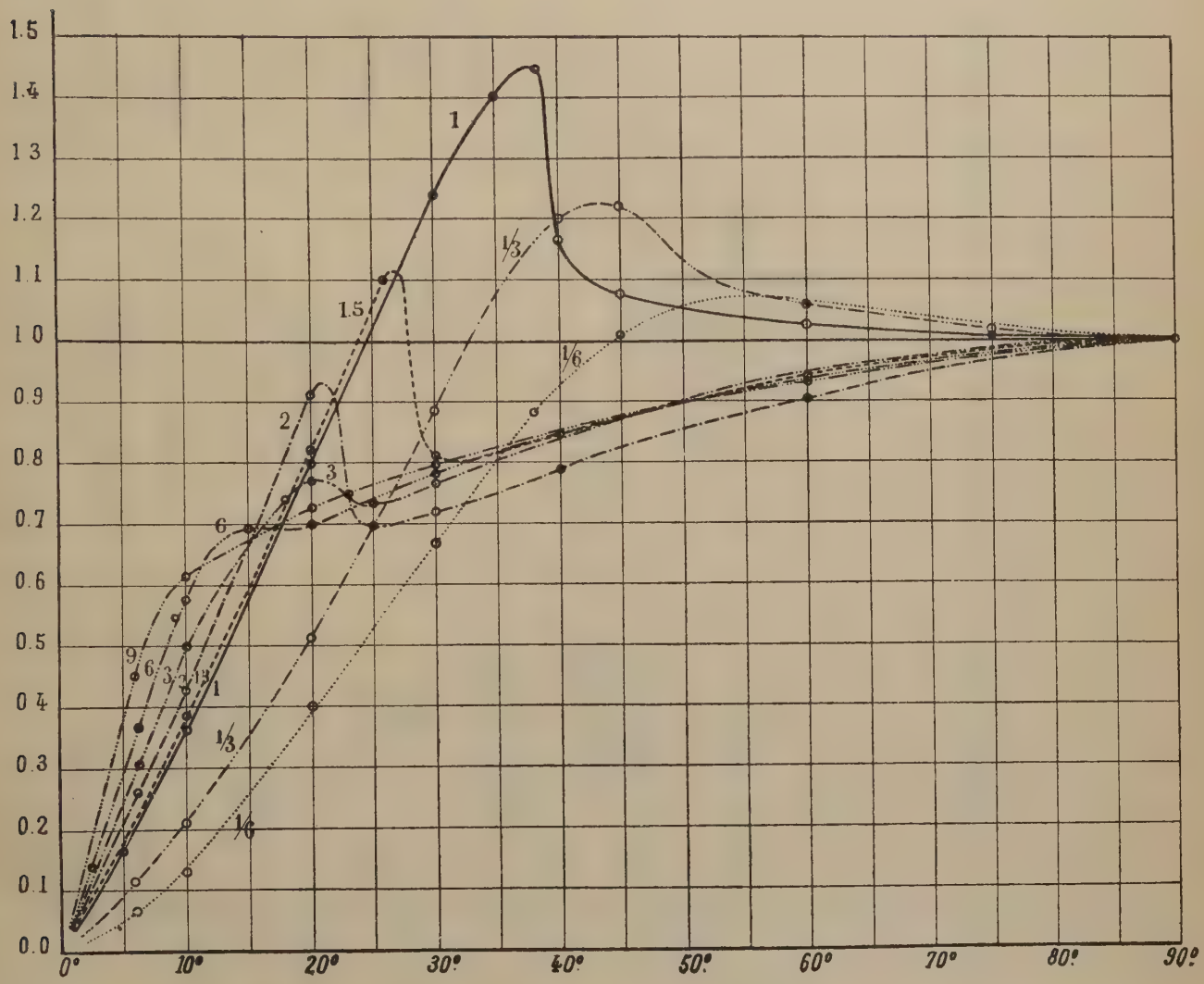


FIG. 7. -- Curves Showing the Effect of the Inclination of Flat Plates to the Current of Air, and Giving the Ratio $\left[\frac{K^1}{K^{90}}\right]$ between the Resistance of the Plate Inclined and Normal to the Current. G. Eiffel.

Courtesy Houghton & Mifflin Co.

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "The Effect of Wind and Fouling Resistances on the U. S. S. Neptune," by William W. Smith, Esq., Member.

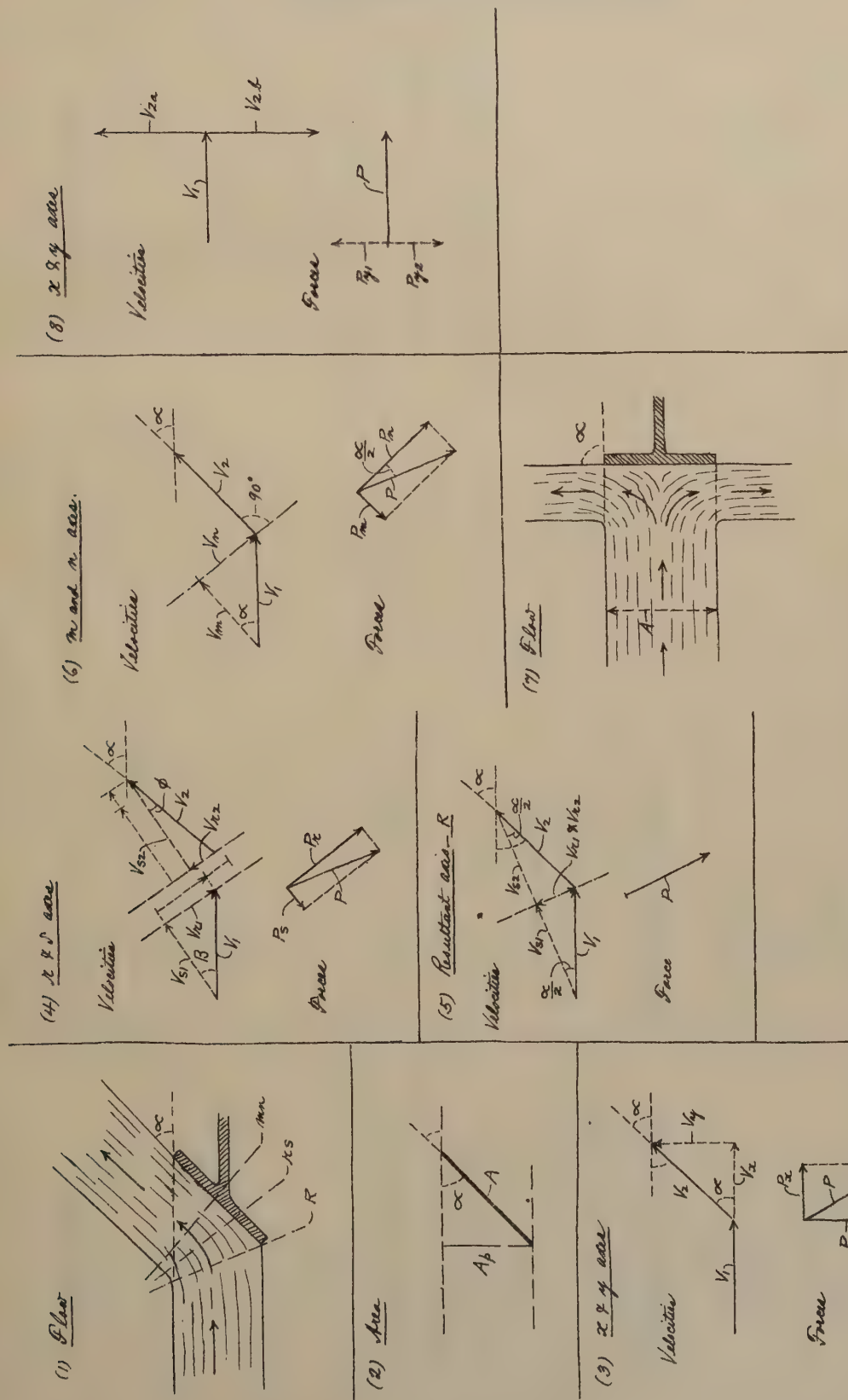


FIG. 8. -- Theoretical Velocity and Force Diagrams for a Current of Air Impinging on a Flat Plate.

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To illustrate paper on "The Effect of Wind and Fouling Resistances on the U. S. S. Neptune," by William W. Smith, Esq., Member.

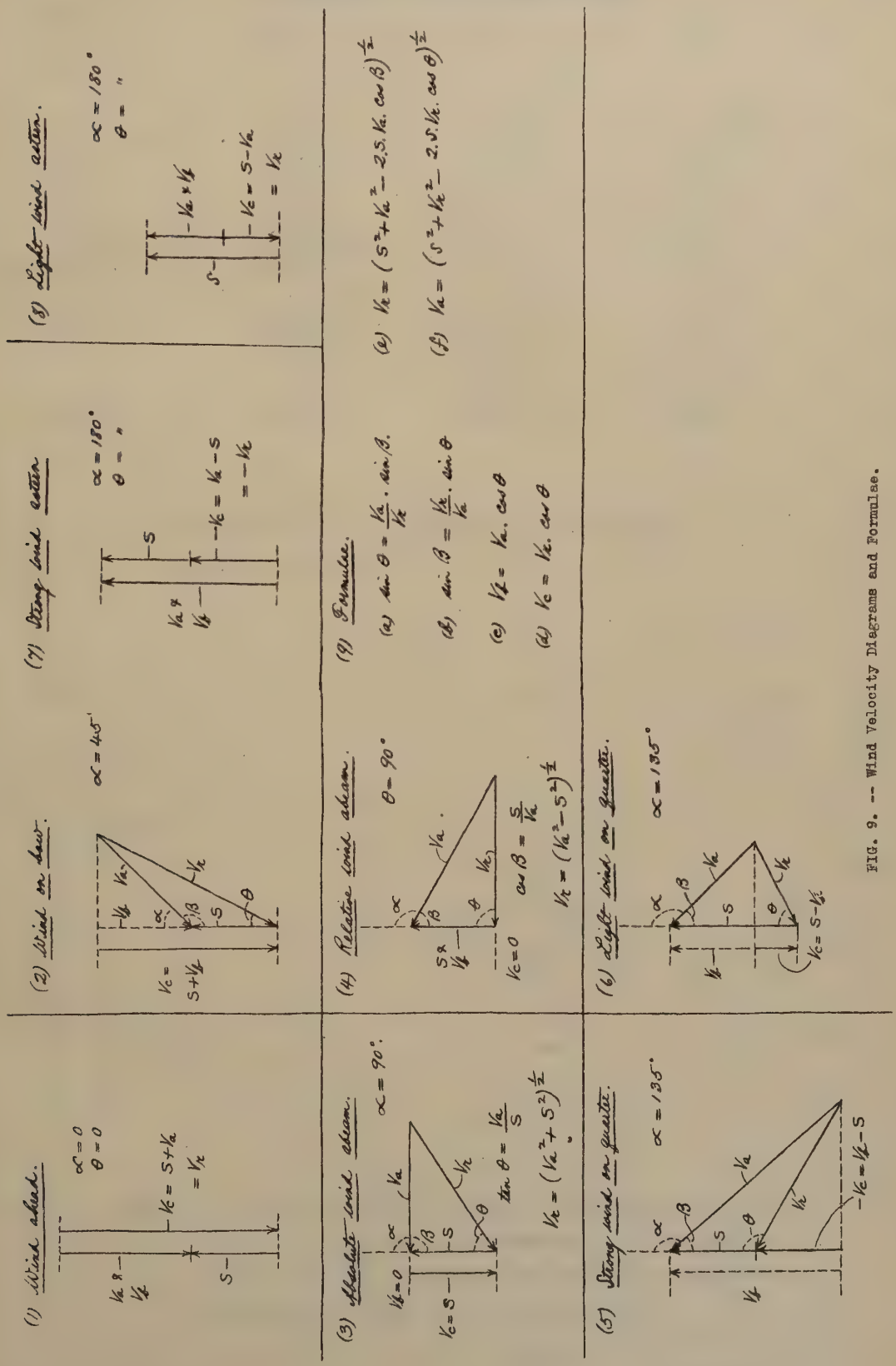

FIG. 9. -- Wind Velocity Diagrams and Formulae.

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To illustrate paper on "The Effect of Wind and Fouling Resistances on the U. S. S. Neptune," by William W. Smith, Esq., Member.

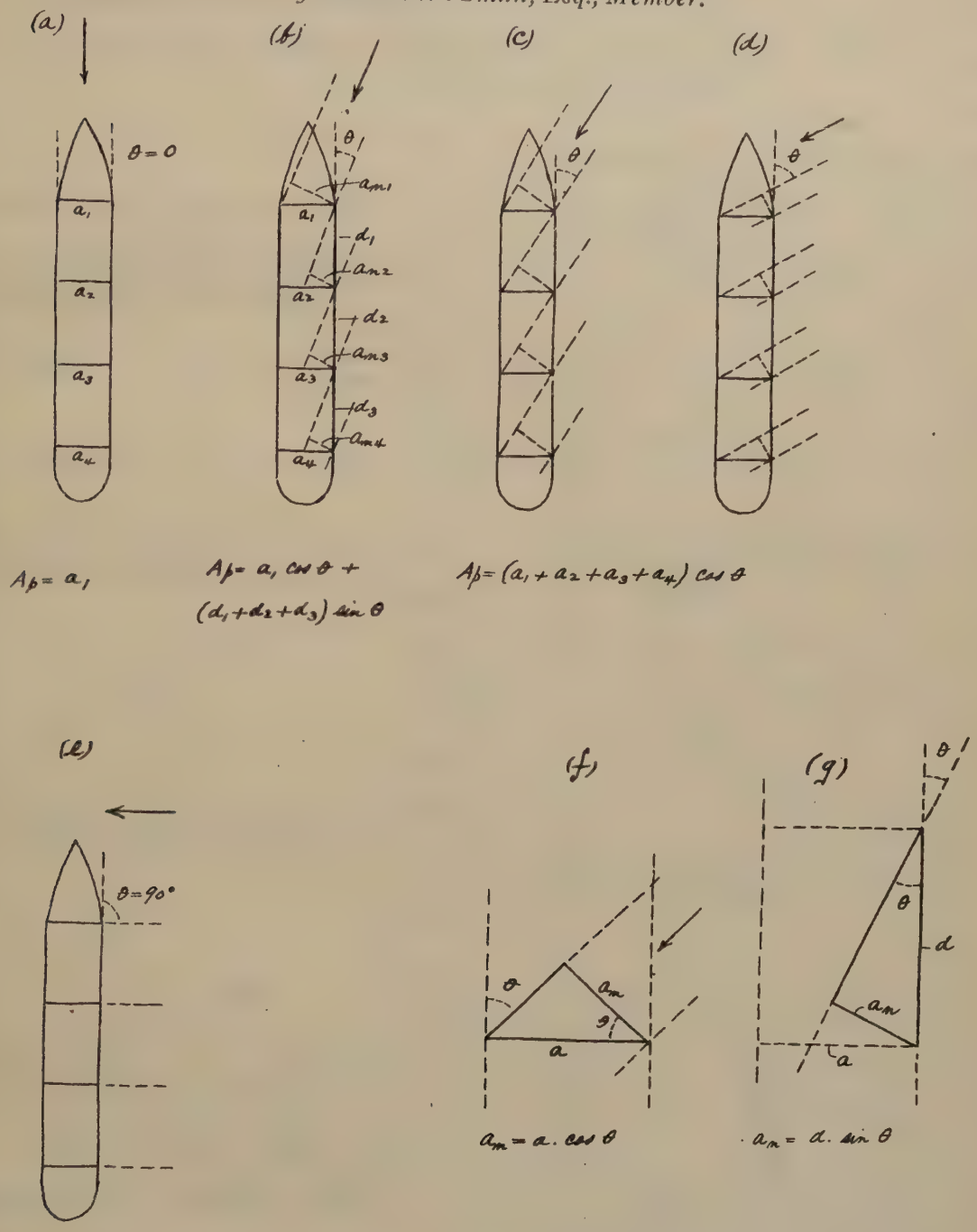


FIG. 10. -- Diagram Showing the Effect of the Direction of the Wind (Relative to the Ship) on the Area and Projected Area Exposed to the Direct Action of the Wind and on the Resistance along the Course for a Theoretical Vessel.

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "The Effect of Wind and Fouling Resistances on the U. S. S. Neptune," by William W. Smith, Esq., Member.

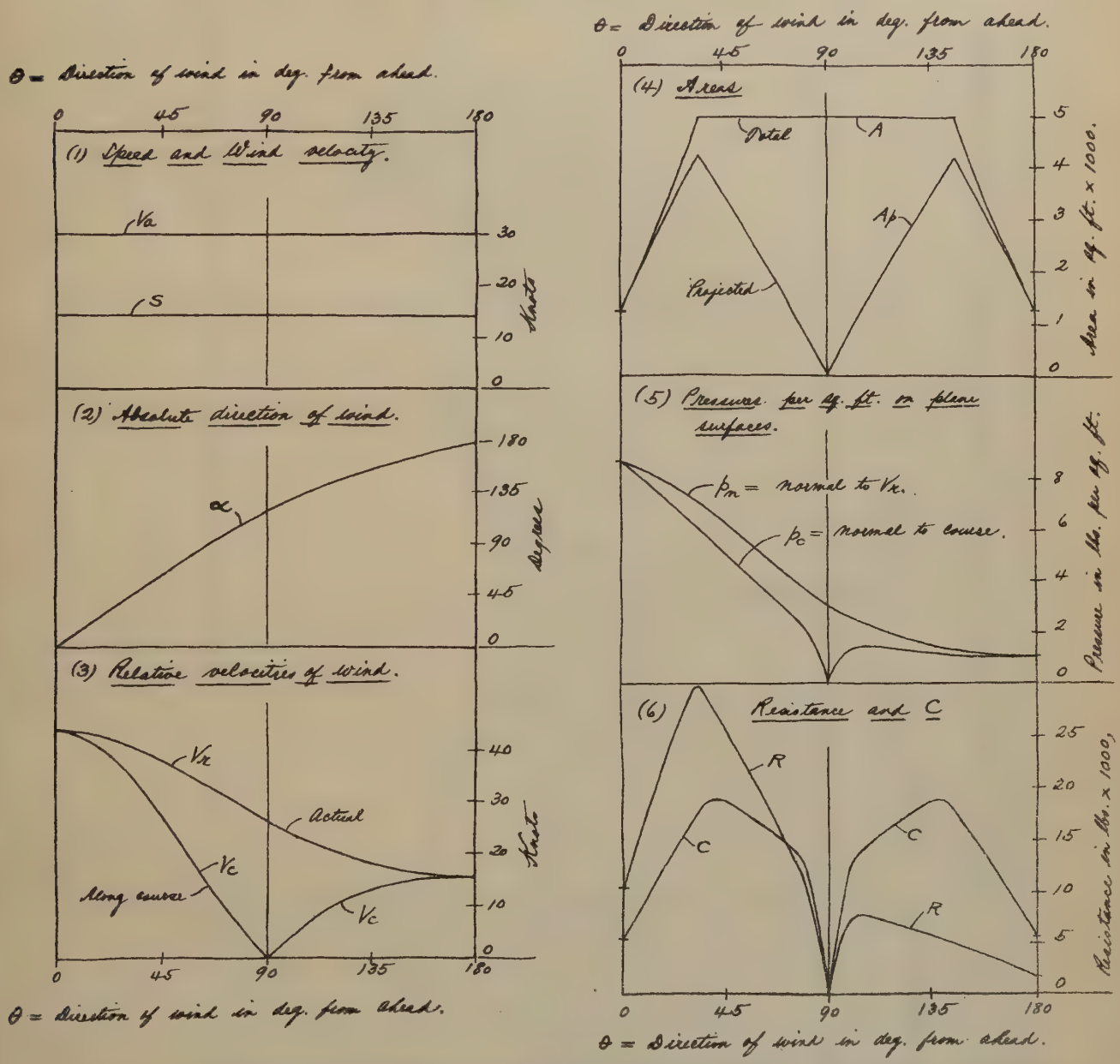
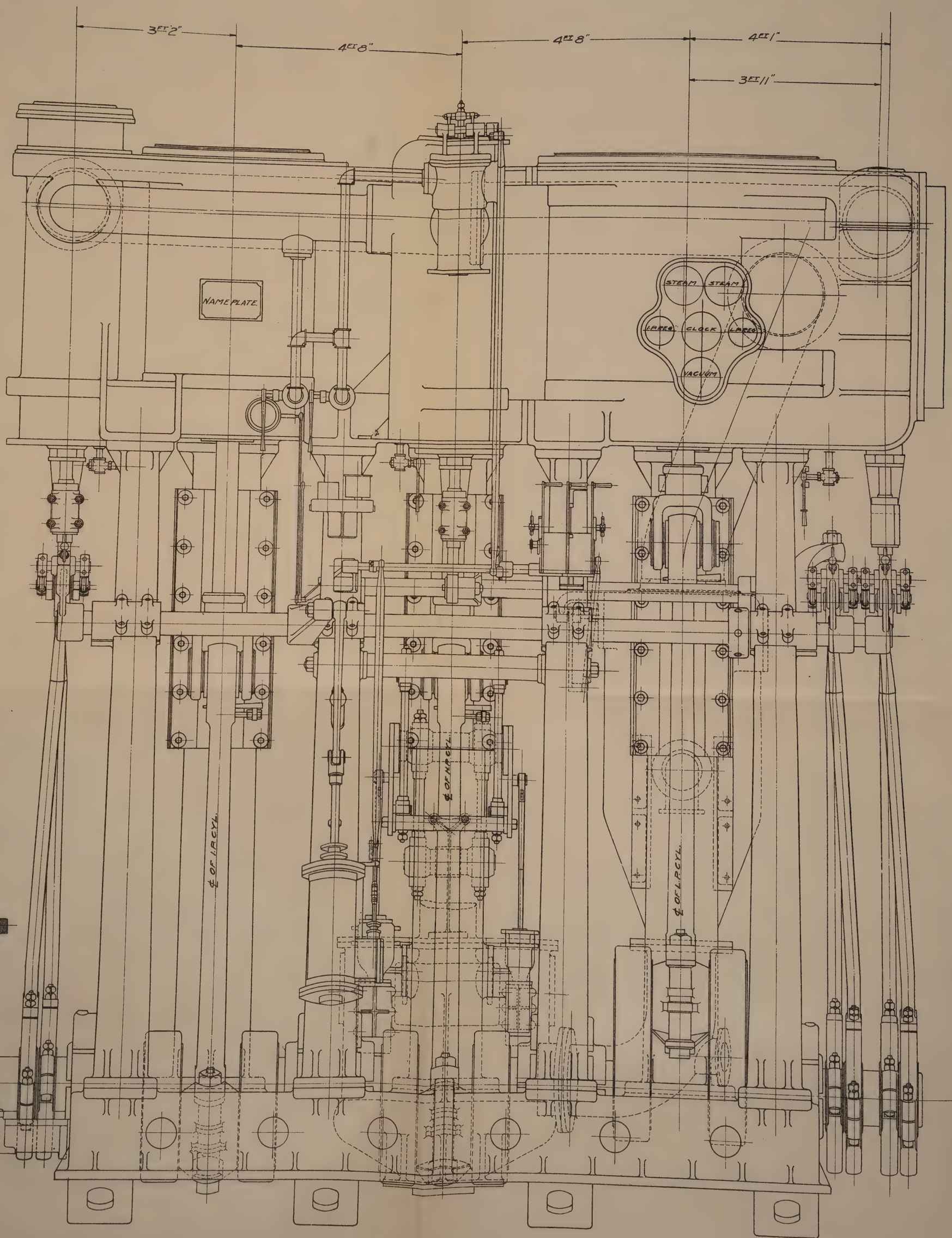


FIG. 11. -- Curves Showing the Effects of the Direction of the Wind on the Theoretical Vessel, Fig. 10.

THE NORRIS PETERS CO., WASHINGTON D. C.

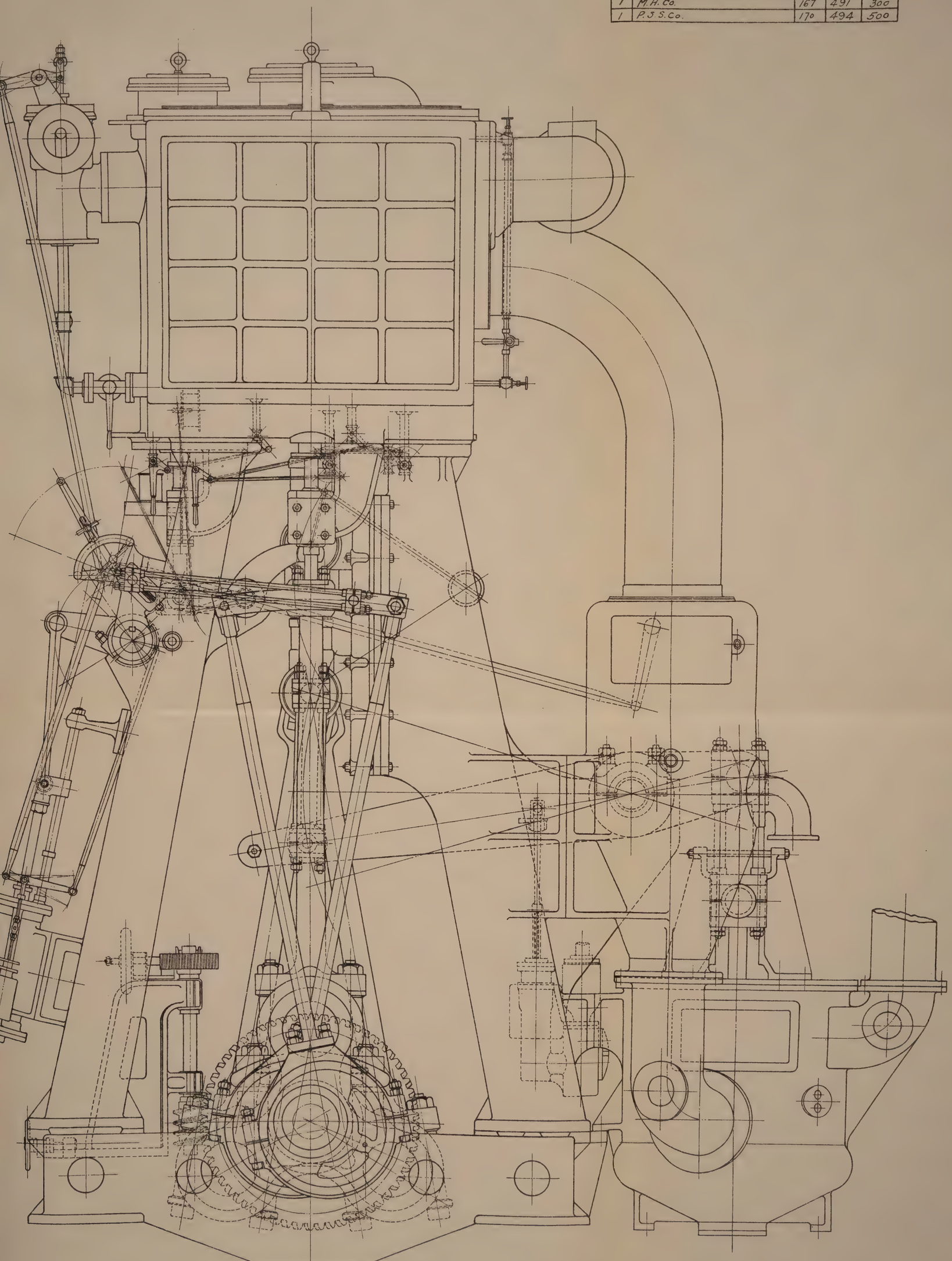
To illustrate paper on "Power and Economy Tests of the S. S. Pontiac," by A. G. Mattsson, Esq., Member, and Thomas Durkin.

To illustrate paper on "Power and Eco
by A. G. Mattsson, Esq., Memb



CONSTRUCTION LIST.

No.	NAME	HULL.	ENG.	ORD.
1	PITTSBURG S.S. CO.	154	478	9800
1	C.C.I. Co.	164	488	9900
1	B.S.S. Co.	166	490	200
1	M.H. Co.	167	491	300
1	P.S.S. Co.	170	494	500



Engineers, Vol. 25, 1917.

To illustrate paper on "Power and Economy Tests of the S. S. Pontiac" by A. G. Mattsson, Esq., Member, and Thomas Durkin.

	U.S. Govt Rules	Lloyds Register
Shell Plates	Pressure $\frac{62720 \times .171875 \times 1.2}{6 \times 81} = 181.5^{\#}$	Pressure $\frac{21.25\,(18.75-2)\,84.6}{162} = 186^{\#}$
Heads in Steam Space	" $\frac{175 \times 17.5^2}{17^2} = 185^{\#}$	" $\frac{175 \times 17.5^2}{17^2 \times .62} = 197^{\#}$
Girders	" $\frac{825 \times 8.75^2 \times .15}{(30.21875-7)\,8.26} = 188^{\#}$	" $\frac{10660 \times 8.75^2 \times .15}{(30-7)\,8.30} = 222^{\#}$
Top of Comb. Chamb	" $\frac{120 \times 10.5^2}{8^2} = 207^{\#}$	" $\frac{100 \times 10.5^2}{8 \times .7^2} = 197^{\#}$
Sides & Back of Comb. Ch.	" $\frac{120 \times 9^2}{6.5^2} = 230^{\#}$	" $\frac{100 \times 9^2}{6.5^2} = 194^{\#}$
Tube Plate	" $\frac{(9.1875-2.784) \cdot .625 \cdot 27000}{31.219 \cdot 4.1875} = 181^{\#}$	" $\frac{1750\,(9.1875-2.784)\,10}{30 \cdot 4.1875} = 196^{\#}$
Main Stays	" $\frac{5.93 \times 9000}{16 \times .17} = 196^{\#}$	$\frac{5.93 \times 10.400}{16 \times .17} = 227^{\#}$
Screw Stays in Sides & Back of Comb Chamb	$\frac{1.024 \times 9000}{6.5^2} = 218^{\#}$	$\frac{1.024 \times 8000}{6.5^2} = 194^{\#}$
Screw Stays in Top of Comb Chamb.	$\frac{1.26 \times 9000}{7 \times 8} = 202^{\#}$	$\frac{1.26 \times 8000}{7 \times 8} = 180^{\#}$
Screw Stays in Back at Vert Edge of Comb. Ch.	$\frac{1.52 \times 9000}{(13+6.5)\cdot 6.5} = 216^{\#}$	$\frac{1.62 \times 8000}{(13+6.5)\,6.5} = 192^{\#}$
Screw Stays in Back at Top of Comb Ch.	$\frac{1.52 \times 9000}{(13+6.5)\,6.5} = 221^{\#}$	$\frac{1.62 \times 8000}{(12.5+6.5)\cdot 6.5} = 197^{\#}$
Screw Stays in Corners of Comb. Ch.	$\frac{2.06 \times 9000}{(13+6.5)^2} = 195^{\#}$	$\frac{2.06 \times 8000}{(13+6.5)(12.5+6.5)} = 200^{\#}$
Front Head Between Nests of Tubes		$\frac{1.40\,(12+\frac{8}{4})^2}{13.5^2} = 196^{\#}$
Rear Head Between Comb Chs		$\frac{.700\,(10+\frac{8}{4})^2}{13.5+6.5^2} = 186^{\#}$
Stress per Sq. Inch in Stay Tubes in Fill		$\frac{(8-8.375-.70686 \times 4)\,180}{1.1888} = 5865^{\#}$
Stress per Sq. Inch in Stay Tubes Betw. Nests		$\frac{(8 \times 10.9375-.70686 \times 3)\,180}{1.8975} = 7470^{\#}$
Round of Bottom of Comb Ch.	$\frac{900 \times 9^2}{7.85 \times 54.875} = 183$	
Thickness of Inner Butt. Strap		$\frac{3 \times 1.171875\,(8.5-1.3125)}{4\,(8.5-2.625)} = 1.0753$

Data for One Boiler	
Heating Surface of Tubes	1770 sq ft
" " Comb. Ch.	204 "
" " Furnaces	113 "
Total Heating Surface	2135 "
Grate Surface 5'6" Grate Bars	45.75
Ratio $\frac{\text{Heating Surface}}{\text{Grate Surface}}$	46.7

Percentage Strength of Joint

Plate: $\frac{(8.5-1.3125)\,100}{8.5} = 84.6\%$

Rivets: $\frac{(4 \times .1353 \times .175 + .1353)\,85}{8.5 \times .171875} = 92.4\%$

Plate + Rivets Combined $\frac{100\,(8.5-2 \times 1.3125)}{8.5} + \frac{1.353 \times 92.4}{10.824} = 80.7\%$

Draft Area thru Tubes: 12.45 ft²

Ratio $\frac{\text{Grate Surf.}}{\text{Draft Area}}$ $\frac{45.75}{12.45} = 3.67$

Butt Straps to be welded on ends to prevent leakage.

Stays threaded thru plate after putting in place, cupped and set up solid

{ Note! - Hull #170 - All Stays Only. - All Stays 2⅞" Dia And

Inside Riveting and Riveting in Furnaces

For Hull #70 only - Eliminate all stay tubes in the nest of tubes, and make every boundary tube a stay tube No. 7 B.W.G.

Two Boiler As Shown One To Other Hand As To Manholes Butts. Etc.

1¼" Rivets 1 13/16" Holes

1¼" Plate

Inner Butt Strap 1 3/8" Thick. Outer " 1" "

1¼" Rivets

13 Spaces @ 8½" = 9 ft

10 ft 0½"

11 ft 2 3/16"

10 ft 4½"

62720# Min. T.S.

5 ft 2"

2⅞" Dia. Body 3¼" Dia. Screw: Standard

Stay Screwed Into Heads - 6 Thds Per In

1⅞" Dia 127

Area At R

Girder

294 Tubes In All 3" Ext. Dia Lap Welded

196 Plain Tubes 3" Ext. Dia #11 B.W.G. Expand

48 Stay Tubes Marked ⊗ 3" Ext. Dia. # 7 B.W.

Each End To 3¼" Ext Dia And Screwed Thru.

50 Tubes Marked ⊗ 3" Ext. Dia. # 10 B.W.G.

Each End To 3¼" Ext Dia. And Screwed Thru

7 ft 8"

2⅞" Dia. Body 3" Dia. Screw

8 ft 2¼"

2⅞" Dia. Body 2¾" Dia Screw.

Leave This Plate Out

Tap for 2" Brass Pipe

For Hull #167 Make This A 4"x6" Hand

11 ft 23/32"

5 ft 3½"

12" Rivets 1⅞" Dia. 10 Thds

2⅞" Dia. Body 2¾" Screw

2⅞" Dia. Body 3" Dia. Screw

1 Rivets 1⅞" Holes - 2½" Pitch - Flush Rivet Outside

½" Doubling Plate

½" Doubling Plate

2⅞" Stay Upset To 3"

4 Rows of Stay Bolts

3 Rows of Stay Bolts

Leave Out This Plate For Hull #170

Put Caulking Strips Under Lugs

12" x 14" x 49½" Lug

⅞" Doubling Plate

⅞" Rivets 15/16" Holes

4 ft 6" On Outside Circle

3 ft 3" On Outside Circle

5 ft 2"

Detail of Riveting at A

1¼" Rivet

1¼" Patch Bolt

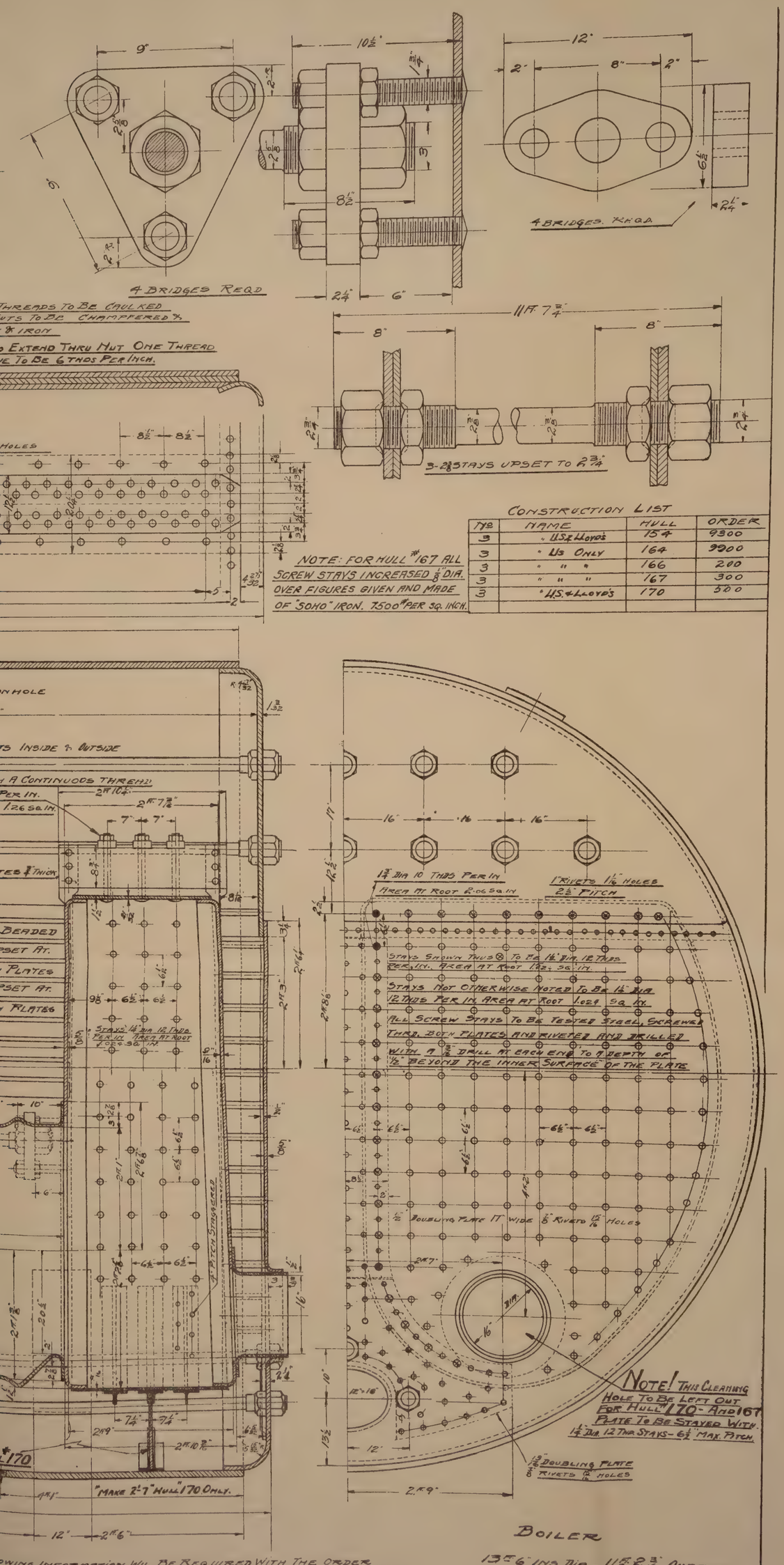
Specification for Rivets U.S. Govt.: Rivets to be of steel tensile strength to be between 55000# and 60000# elongation to be 30% in 8" inches must test hot and cold by driving down on an anvil with the head in the die. Must test by nicking and bending back on themselves cold without developing cracks or flaws

Riveting: All holes to be drilled: All rivetholes slightly countersunk

Shell Longitudinal Seams	1¼" Rivets	1 5/16" Holes	
Shell Circumferential Joint Ends	1¼" Rivets	1 5/16" Holes	
Front Head Horiz. Joint	1" Rivets	1 1/16" Holes	2½" Pitch
Back " " "	1 "	1 1/16" "	2½" "
Furnaces & Comb. Chamb	⅞" "	15/16" "	2⅝" "
Stiffening Bars	⅞" "	15/16" "	2½" "
Doubling Plate	⅞" "	15/16" "	2⅝" "

Tensile Strength

Thos. Norris Peters Co., Washington, D. C.



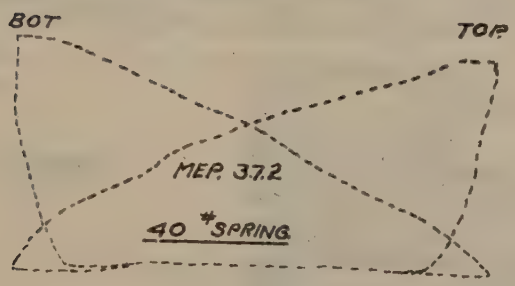
CONSTRUCTION LIST

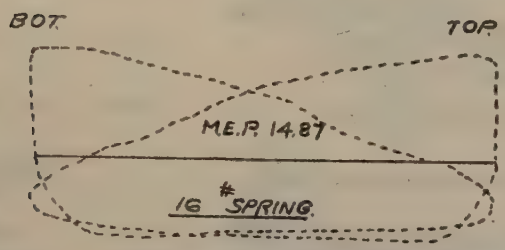
Nº	NAME	HULL	ORDER
3	" U.S. & Lloyd's	154	9300
3	" U.S. ONLY	164	9900
3	" " "	166	200
3	" " "	167	300
3	" U.S. & LLOYD'S	170	500

To illustrate paper on "Power and Economy Tests of the S. S. Pontiac," by A. G. Mattsson, Esq., Member, and Thomas Durkin.

TEST S.S PONTIAC

AUGUST-22-1917.





ENGINE - 24½"-40"-65"-42" STROKE.

BOILER PRESSURE	182 #	M.E.P.-H.P.	76 #.
I.P. RECEIVER	80 #	M.E.P.-I.P.	37.2 #
L.P. RECEIVER	14 #	M.E.P.-L.P.	14.87 #
VACUUM	22"	I.H.P. – H.P. CYL.	662
R.P.M.	87.16	I.H.P. – I.P. CYL.	864
PISTON SPEED	610	I.H.P. – L.P. CYL.	916
REF. M.E.P. TO L.P.	39.8	TOTAL I.H.P.	2441
CUTS ALL OFF			

CARDS TAKEN 2:00 P.M.

THE NORRIS PETERS CO., WASHINGTON, D. C

To illustrate paper on "Power and Economy Tests of the S. S. Pontiac," by A. G. Mattsson, Esq., Member, and Thomas Durkin.

TRIAL OF S.S. PONTIAC.

BY MESSRS. MATTSON-DURKIN-BRETZ. LAKE HURON.
BETWEEN DETOUR AND THUNDER BAY. AUGUST-28-1917.

HULL — 600'0" OVERALL - 580'0" KEEL - 60'0" BEAM - 32'0" DEPTH.
DRAUGHT 20'-9" FORD - 20'-8" AFT.
LOAD 12,187 GROSS TONS OF IRON ORE.
ENGINE. TRIPLE EXPANSION - 24½"-40"-65" X 42"
AIR PUMP - 14" STROKE - 39" DIA. - 16" SUCTION - 12" DISCHARGE.

BOILERS

3 CYLINDRICAL 13'6" DIA. 11'2" — OVERALL.
PRESSURE ALLOWED 180# PER. SQ. IN 6 - FURNACES 50" DIA.
GRATE BARS 5'6" LONG. - TOTAL GRATE SURFACE = 137.25 □'
TOTAL HEATING SURFACE = 6405 □'

$\frac{\text{HEATING SURF.}}{\text{GRATE SURF.}} = 46.7$

DISPLACEMENT

NET. TONS - 19350 GROSS TONS. - 17277

POSITIVE HEATED DRAFT.

BLOWER - SIROCCO FAN DIA. WHEEL = 36" SUCT. = 2'7¾" X 3'0" DISCH.
BLOWER ENGINE - 6" X 6" VERTICAL DIRECT CONNECTED
HEATER - SCHUETTE AND KOERTLING. #12 - 20" DIA. - 66" LONG.
PROPELLER - DIA = 13'0" PITCH - 13'9" DEVELOPED AREA = 83 □'

DURATION OF TEST (12:57 P.M. TO 6:48 P.M.) 5 HRS 51 MIN.
INDICATOR CARDS TAKEN EVERY 60 MIN

BOILER PRESSURE	182#	DRAFT AT ASH PIT.	.48
I.P. RECEIVER	80#	" " " AIR CASING	.8
L.P. RECEIVER	14#	" " " FAN	.9
VACUUM.	21.5#	REV. OF FAN -	540
REV. PER. MIN. AVERAGE	87.16	COAL - (GOOD QUALITY OF RUN OF MINE	
PISTON SPEED	610	COAL TOTAL 6 HRS. - 7 MIN.	19972 #
M.E.P. H.P. CYL.	76	ASH TOTAL 6 HRS. 7 MIN.	1854#
M.E.P. I.P. CYL	37.2	ASH % (MOIST)	9.3%
M.E.P. L.P. CYL.	14.87	COMBUSTIBLE (TOTAL)	18118
R.E.P. M.E.P. TO L.P	39.8	" " " PER. HOUR.	2961
I.H.P. H.P. CYL.	662	" " " PER. H.P. HOUR. -	1.23
I.H.P. I.P. CYL.	864	" " " PER. SQ. FT. GRATE.	21.6
I.H.P. L.P. CYL.	915	COAL PER. HR.	3265#
TOTAL I.H.P.	2441	COAL PER. I.H.P.	1.34
		COAL PER. □' OF GRATE.	23.8

$\frac{\text{I.H.P}}{\text{GRATE SURF.}} = 17.78$

$\frac{\text{HEATING SURF.}}{\text{I.H.P.}} = 2.63$

WEATHER - FINE - NO WIND.

$C = \frac{D^{2/3} \times S^3}{\text{I.H.P}} = 351$

$\frac{\text{I.H.P} \times 33000}{P \times R} = 67310$

TEMP. OF ENGINE ROOM -	90°	OZ. OF COAL PER. TONS MILE =	.31
" " " FIRE HOLD.	88°		
" " " STACK.	543°		
" " " AIR CASING.	230°	SLP (USING 13'9" AS MEAN PITCH	8.4%
" " " ASH PIT.	252°	SPEED OF SHIP - 12.5 MI. PER. HR.	
" " " FEED HEATER.	186°	FROM DETOUR TO THUNDER BAY = 73 MI. - 5 HR. - 51 MIN.	
" " " HOTWELL. -	132°	3 - LEARMONT PURIFIERS - 3'-6" DIA - 8'-6" HIGH.	
" " " INJ. WATER.	54°	MECHANICAL FLUE BLOWERS.	
		STACK - 60' HIGH - 6'-6" INSIDE DIA.	
		AIR HEATER - 4' HIGH - 2¾" DIA. TUBES -	
		HEATING SURFACE = 2505 □'	

AVERAGE FLUE GAS ANALYSIS = 14% - CO^2.

$\frac{20000 \times 2441}{1284 \times 600 \times 100} = .63$

FUEL ANALYSIS
ASH - 8.05
SULPHUR 1.73
B.T.U. - 13626.
FUEL ANALYSIS BY DET. TESTING LABORATORY

THE NORRIS PETERS CO., WASHINGTON, D.C.

To illustrate paper on "Devices for Comparing the Rotation of Shafts," by Dr. K. Suyehiro, Member.

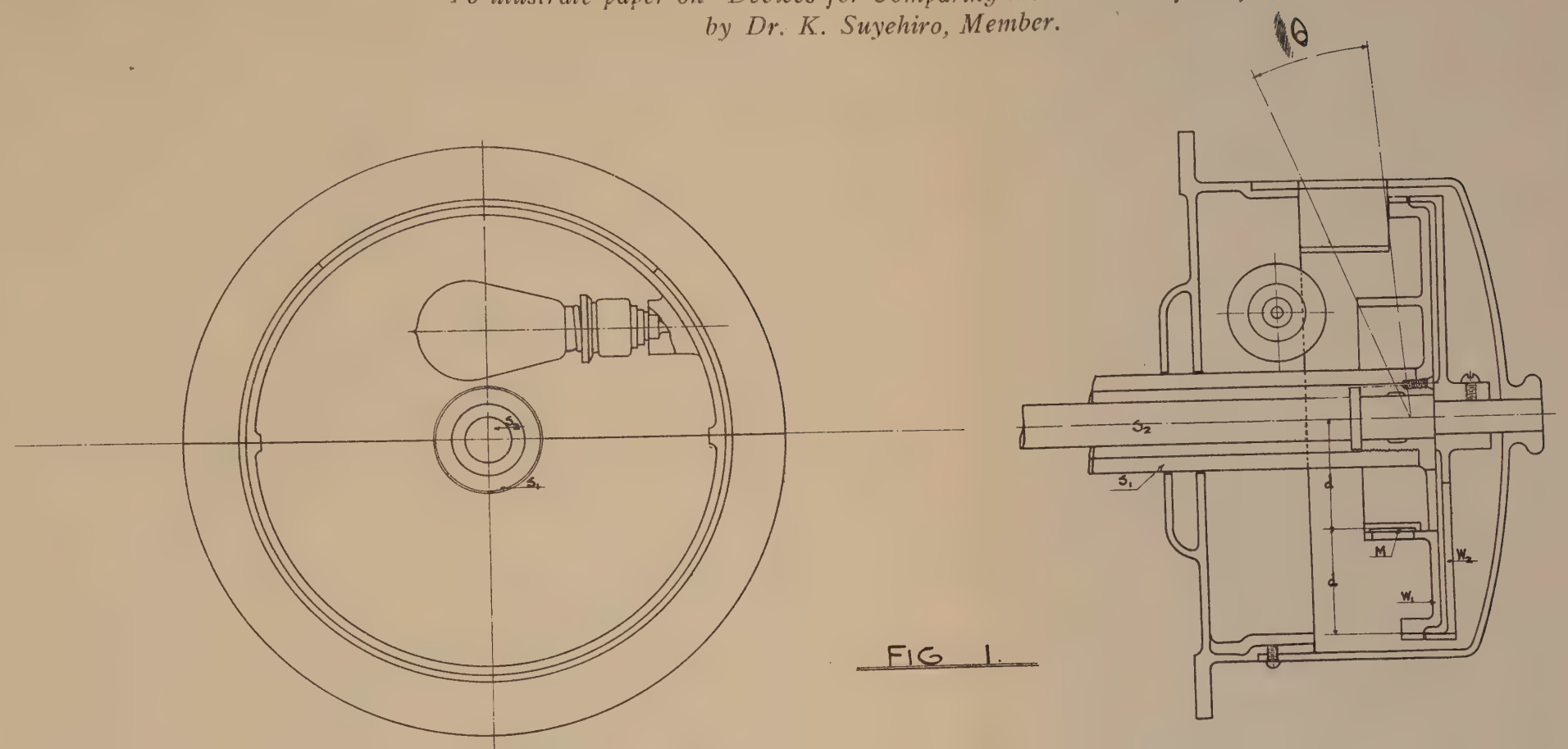


FIG 1.

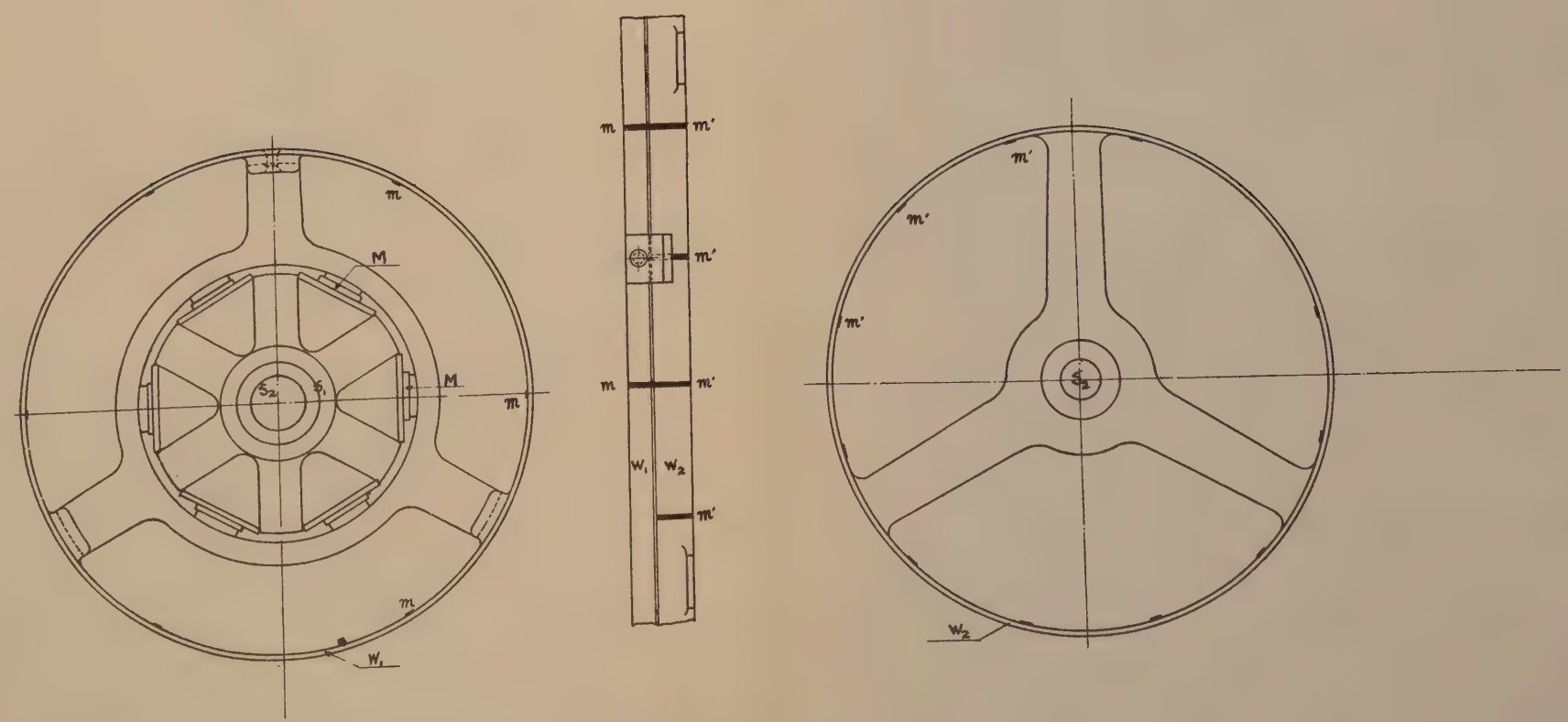


FIG 2.

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To illustrate paper on "Devices for Comparing the Rotation of Shafts," by Dr. K. Suyehiro, Member.

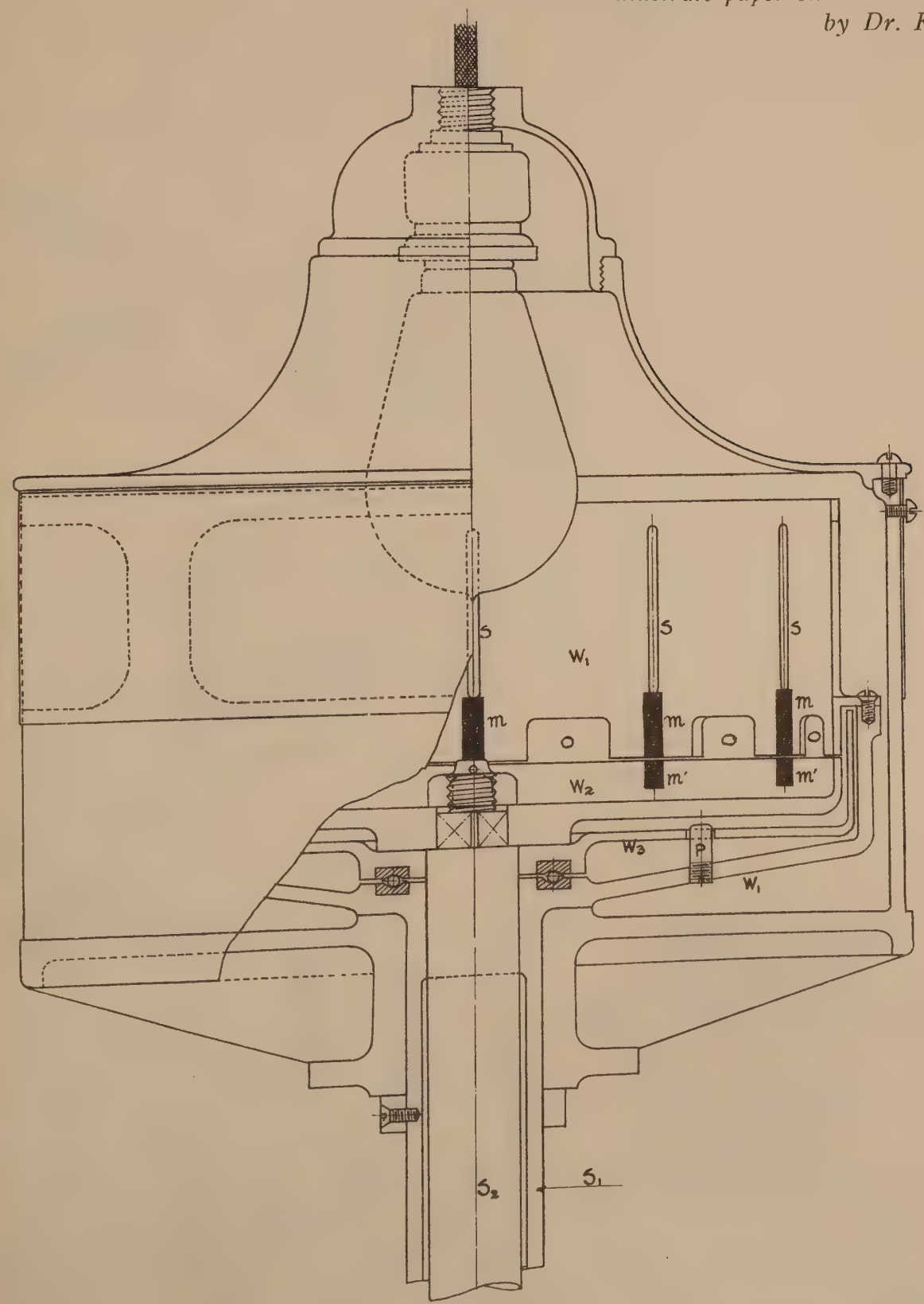

FIG. 1.

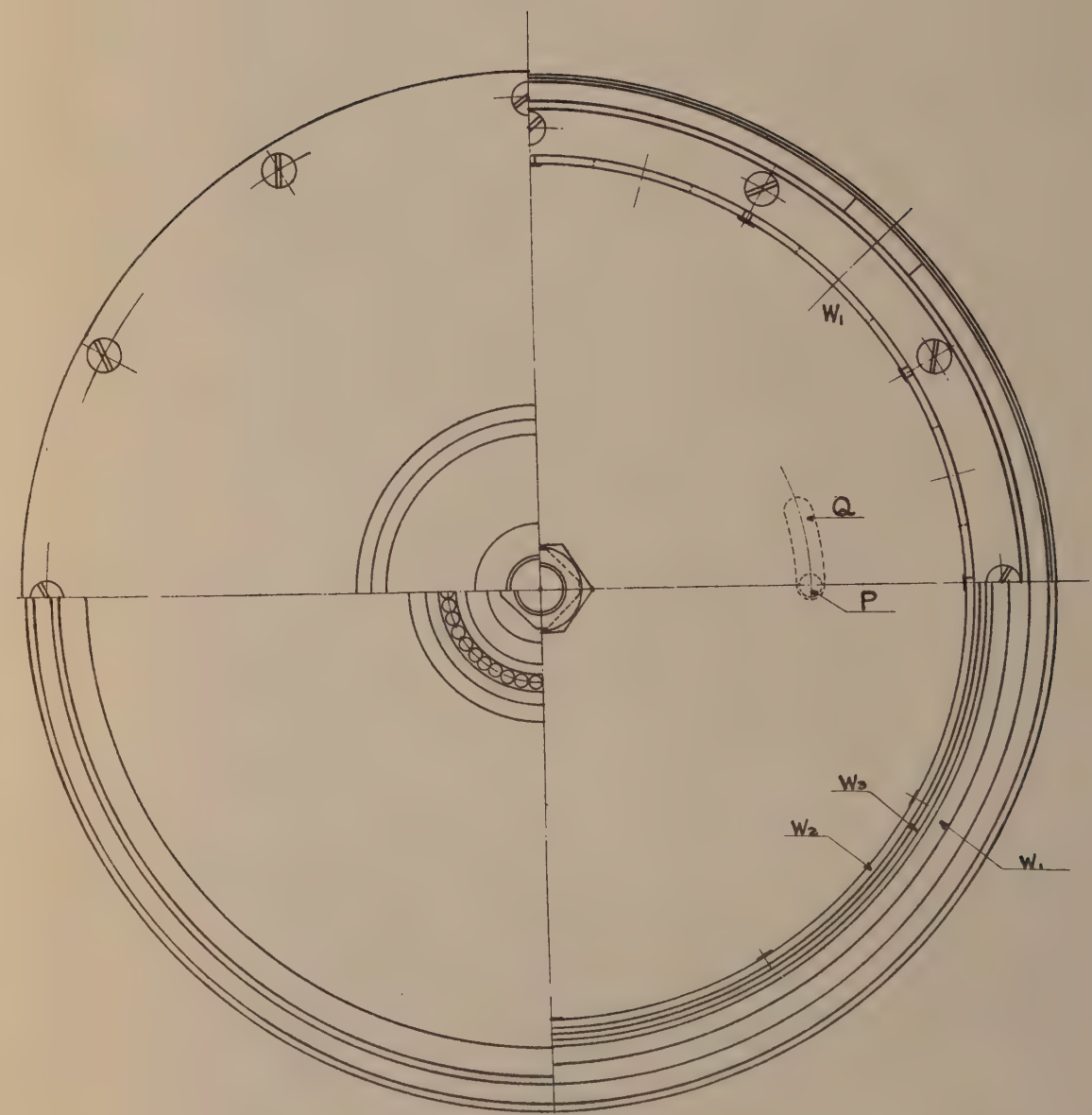

FIG. 2.

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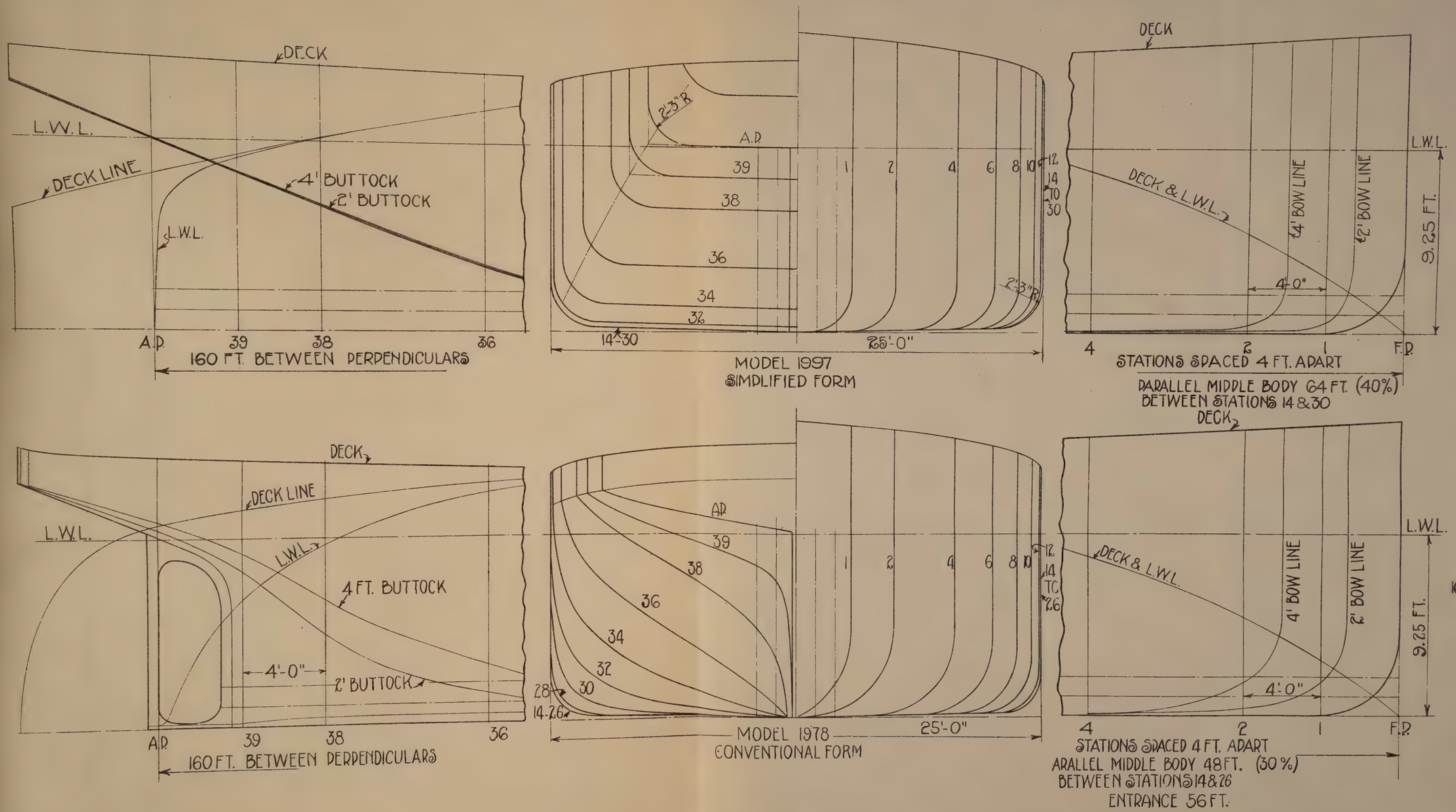
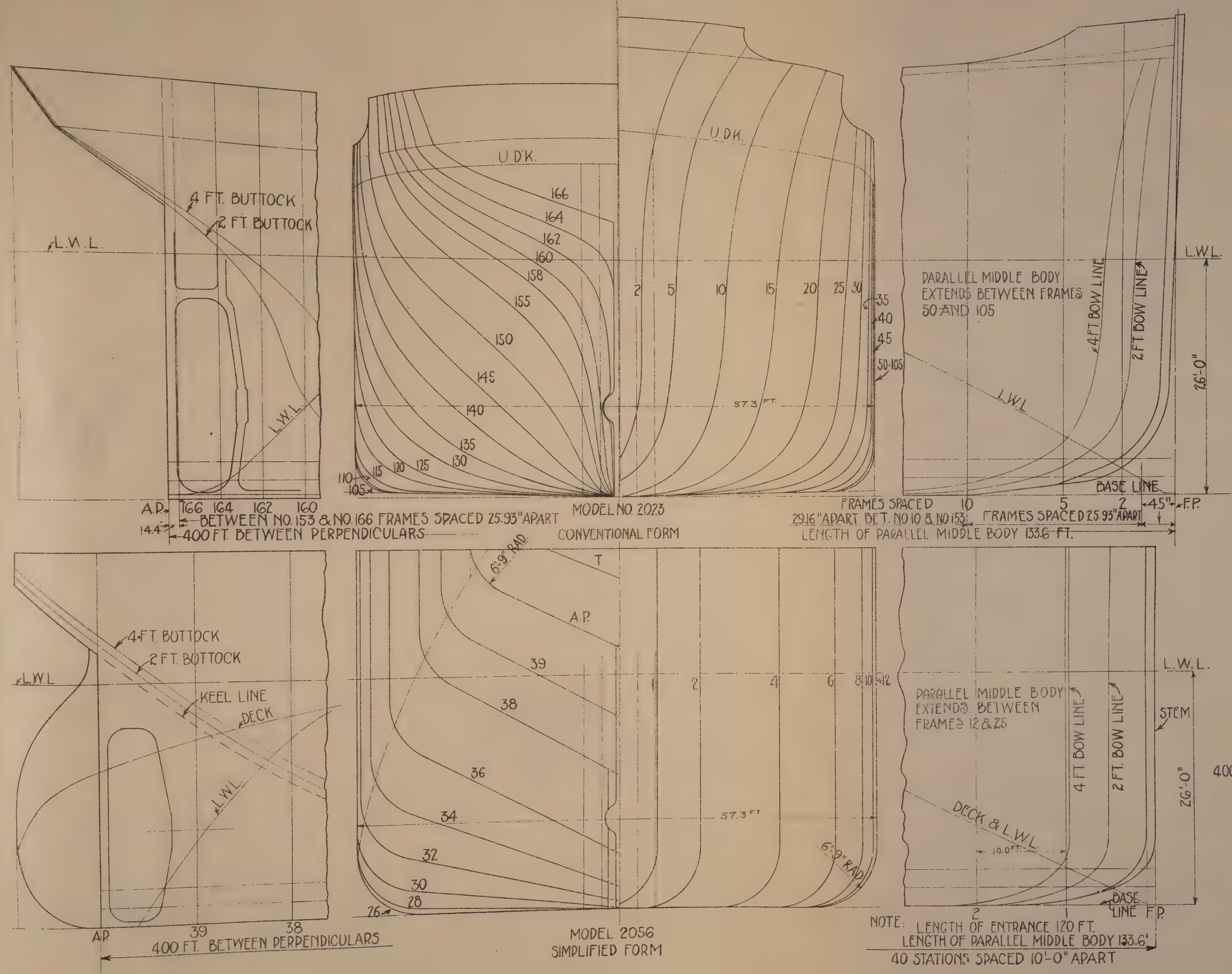
To illustrate paper on "Cargo Ship Lines of Simple Form," by Naval Constructor William McEntee, U. S. N., Member.



LINES OF MODELS
NOS. 1978 AND 1997
REPRESENTING
160 FT. × 25 FT. × 9.25 FT. × 830 TONS
FUEL OIL BARGES
OF
CONVENTIONAL FORM
AND OF
SIMPLIFIED LINES

THE NORRIS PETERS CO., WASHINGTON, D. C.

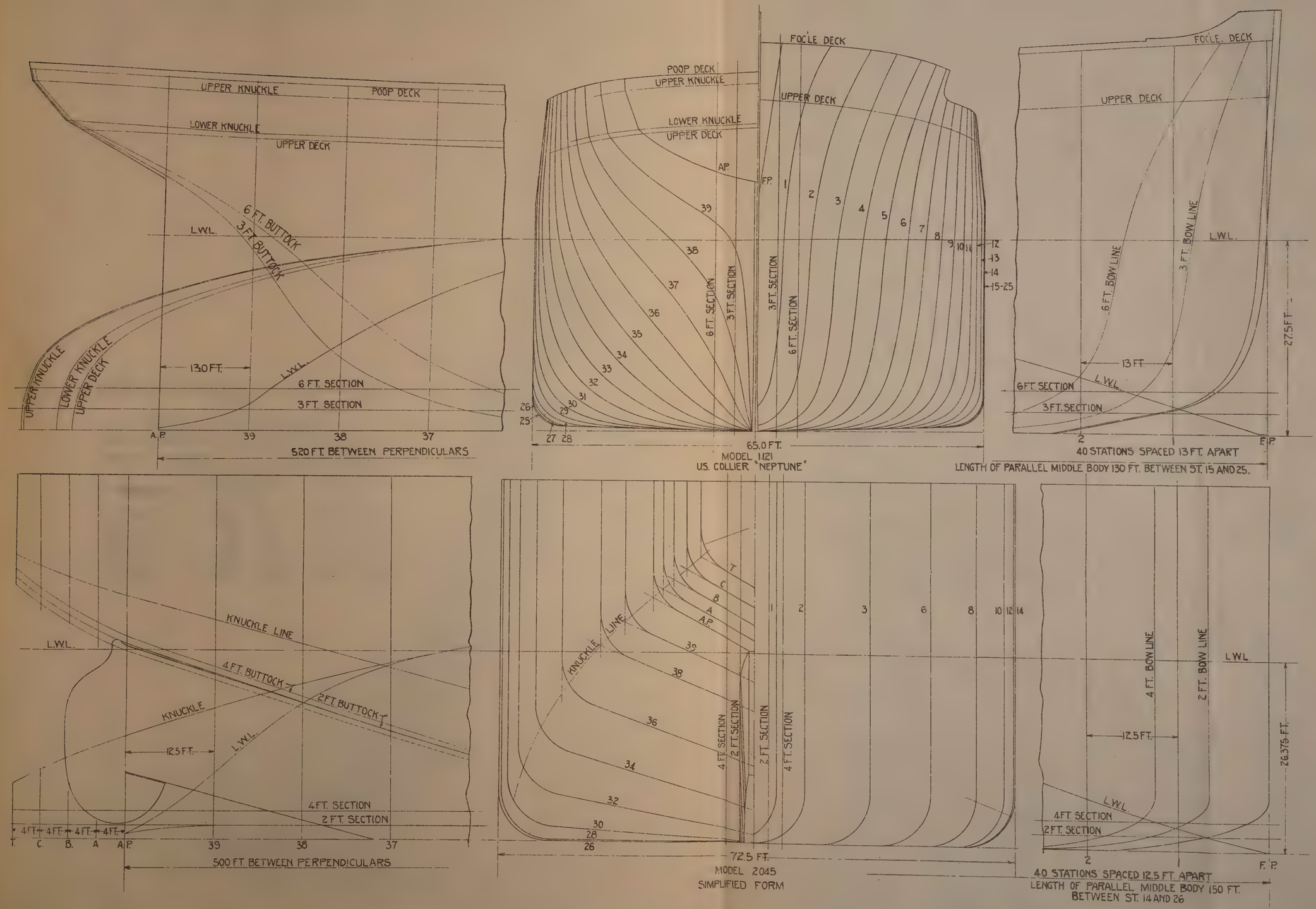
To illustrate paper on "Cargo Ship Lines of Simple Form," by Naval Constructor William McEntee, U. S. N., Member.



LINES OF MODELS NOS. 2023 AND 2056 REPRESENTING 400 FT. × 57.3 FT. × 26 FT. × 13,137 TONS CARGO SHIPS OF CONVENTIONAL FORM AND OF SIMPLIFIED FORM

THE NORRIS PETERS CO., WASHINGTON D. C.

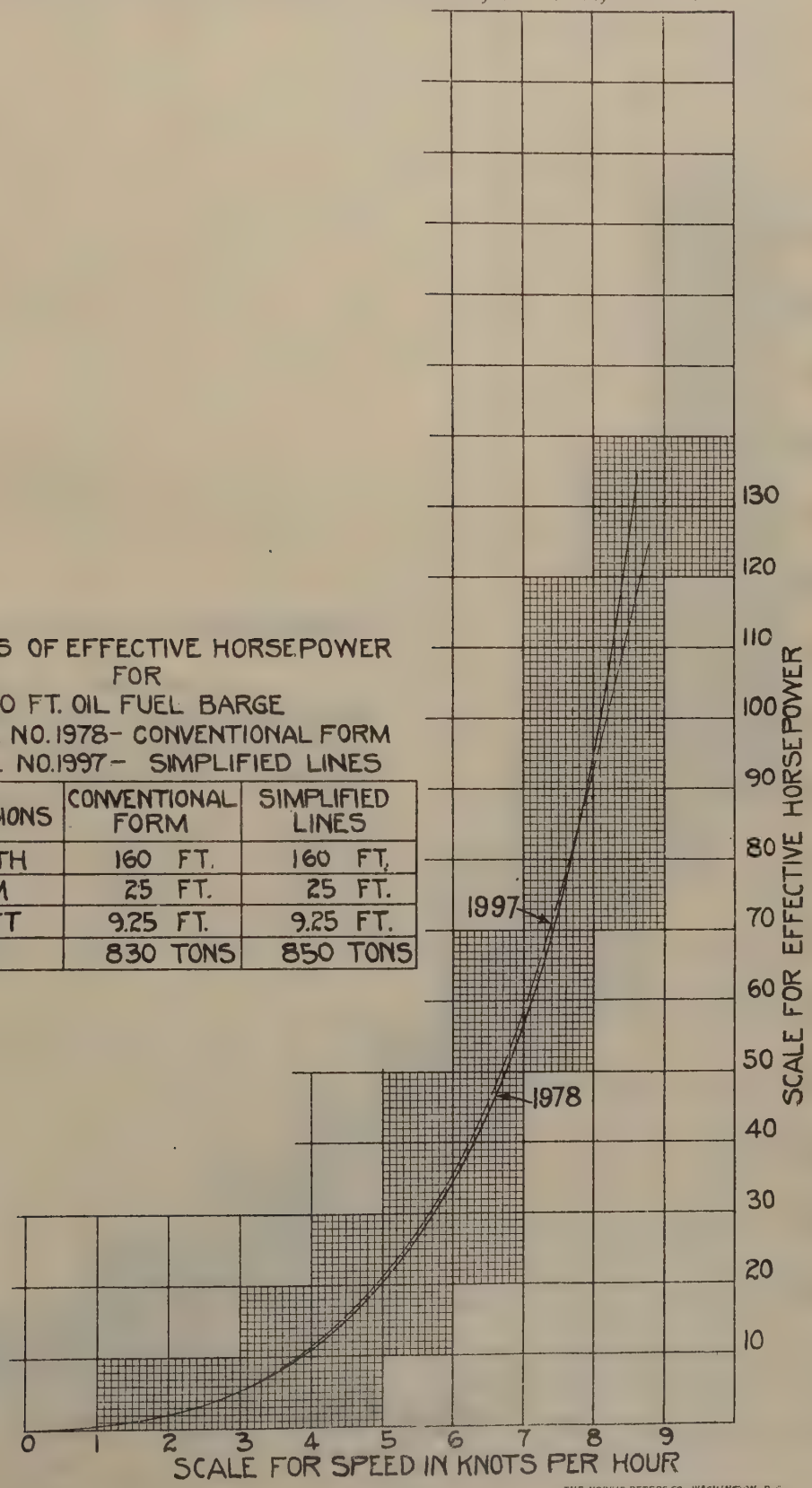
To illustrate paper on "Cargo Ship Lines of Simple Form," by Naval Constructor William McEntee, U. S. N., Member.



LINES OF MODELS
NOS. 2045 AND 1121
REPRESENTING
500 FT. × 72.5 FT. × 26.375 FT. × 20000 TONS
CARGO SHIP OF SIMPLIFIED LINES
AND
520 FT. × 65 FT. × 27.5 FT. × 19340 TONS
COLLIER

THE NORRIS PETERS CO., WASHINGTON, D.C.

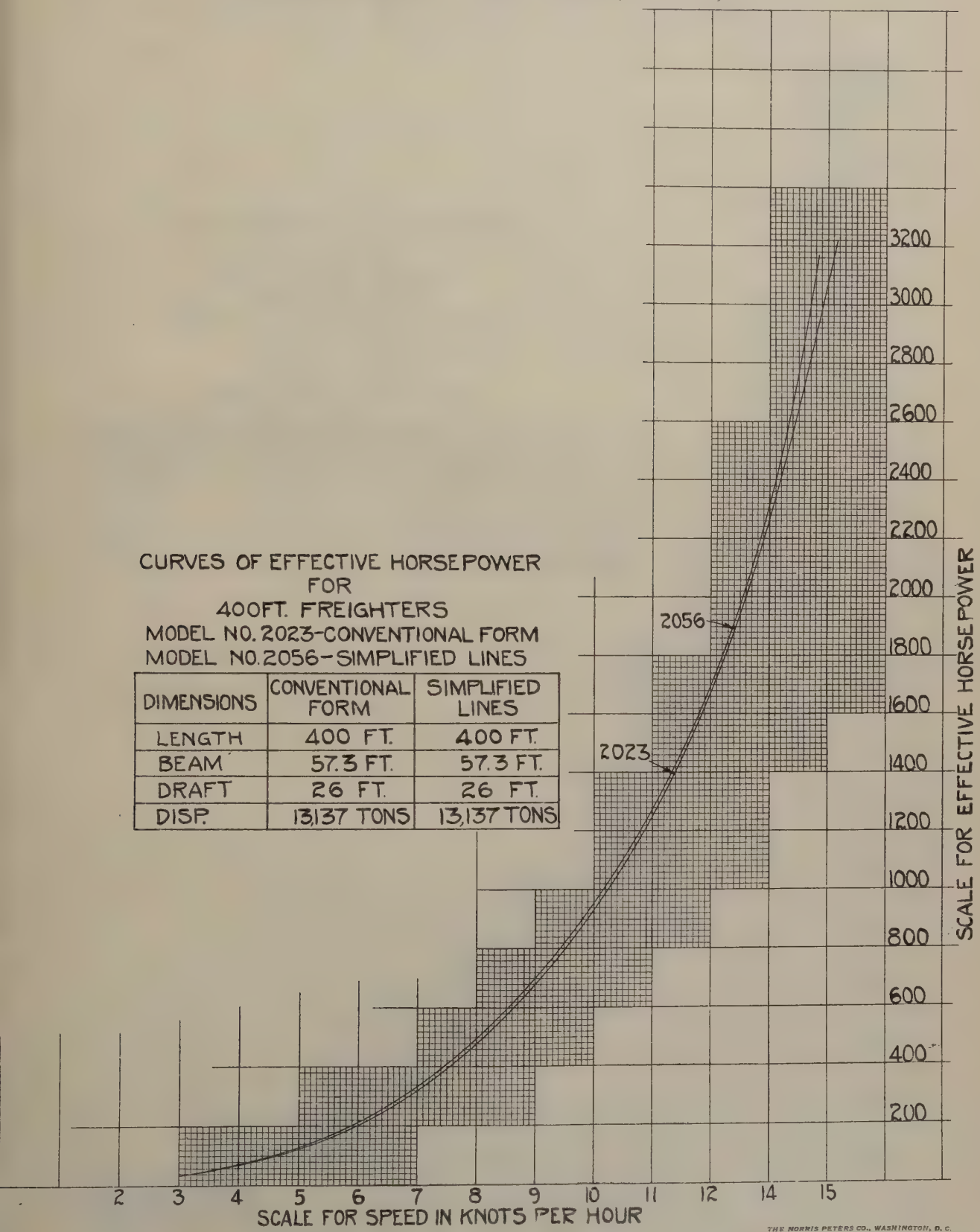
To illustrate paper on "Cargo Ship Lines of Simple Form," by Naval Constructor William McEntee, U. S. N., Member.



DIMENSIONS	CONVENTIONAL FORM	SIMPLIFIED LINES
LENGTH	160 FT.	160 FT.
BEAM	25 FT.	25 FT.
DRAFT	9.25 FT.	9.25 FT.
DISP.	830 TONS	850 TONS

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "Cargo Ship Lines of Simple Form," by Naval Constructor William McEntee, U. S. N., Member.



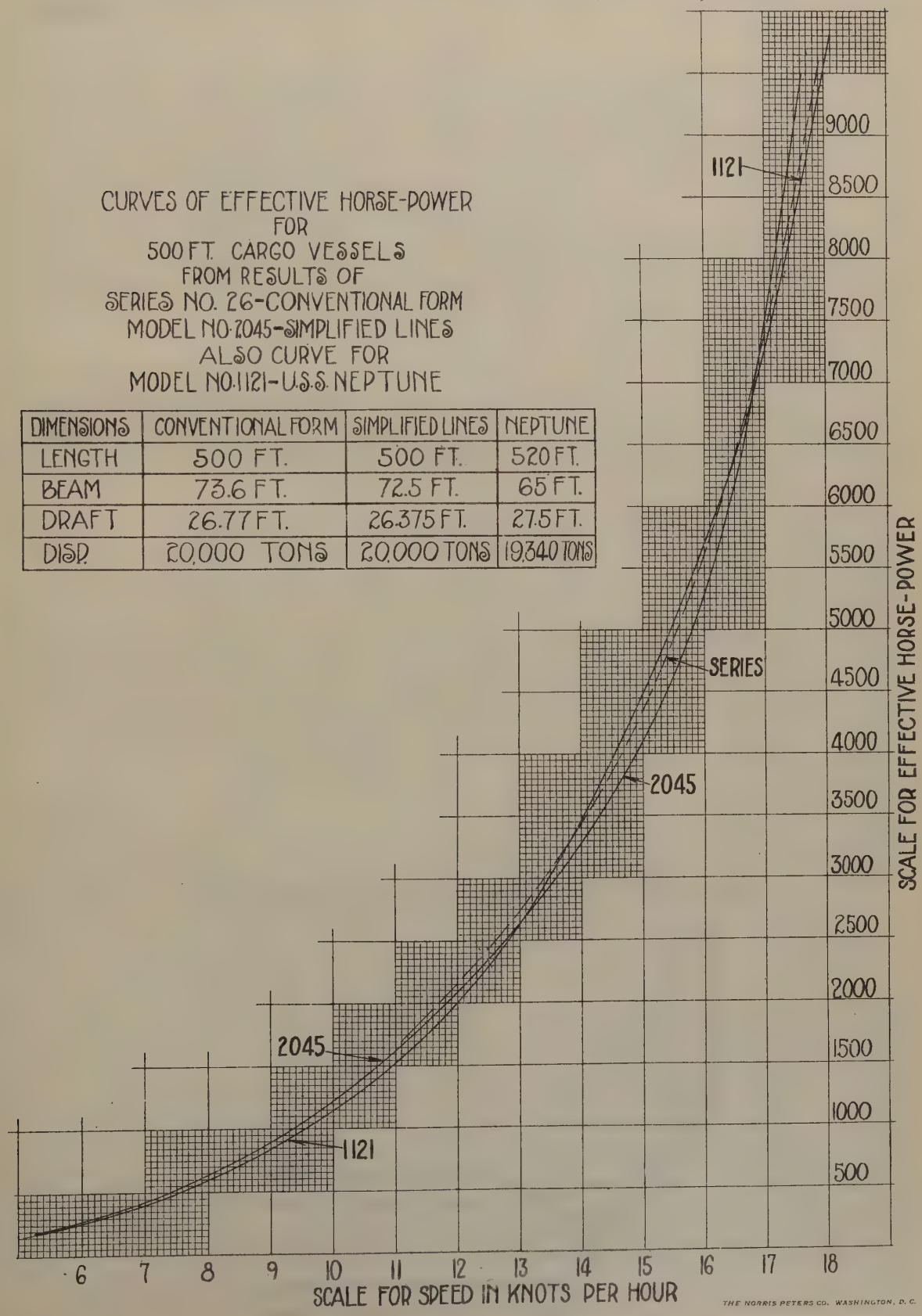
DIMENSIONS	CONVENTIONAL FORM	SIMPLIFIED LINES
LENGTH	400 FT.	400 FT.
BEAM	57.3 FT.	57.3 FT.
DRAFT	26 FT.	26 FT.
DISP.	13,137 TONS	13,137 TONS

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "Cargo Ship Lines of Simple Form," by Naval Constructor William McEntee, U. S. N., Member.

CURVES OF EFFECTIVE HORSE-POWER
FOR
500 FT. CARGO VESSELS
FROM RESULTS OF
SERIES NO. 26-CONVENTIONAL FORM
MODEL NO. 2045-SIMPLIFIED LINES
ALSO CURVE FOR
MODEL NO. 1121-U.S.S. NEPTUNE

DIMENSIONS	CONVENTIONAL FORM	SIMPLIFIED LINES	NEPTUNE
LENGTH	500 FT.	500 FT.	520 FT.
BEAM	73.6 FT.	72.5 FT.	65 FT.
DRAFT	26.77 FT.	26.375 FT.	27.5 FT.
DISP.	20,000 TONS	20,000 TONS	19,340 TONS



THE NORRIS PETERS CO. WASHINGTON, D. C.

To illustrate discussion by Professor Herbert C. Sadler, Member of Council, on paper entitled "Cargo Ship Lines of Simple Form," by Naval Constructor William McEntee, U. S. N., Member.

Fig. 1

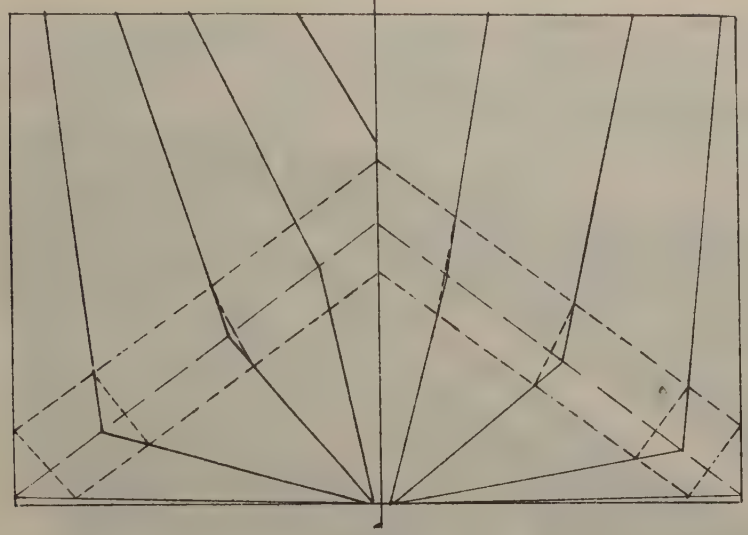


Fig. 2.

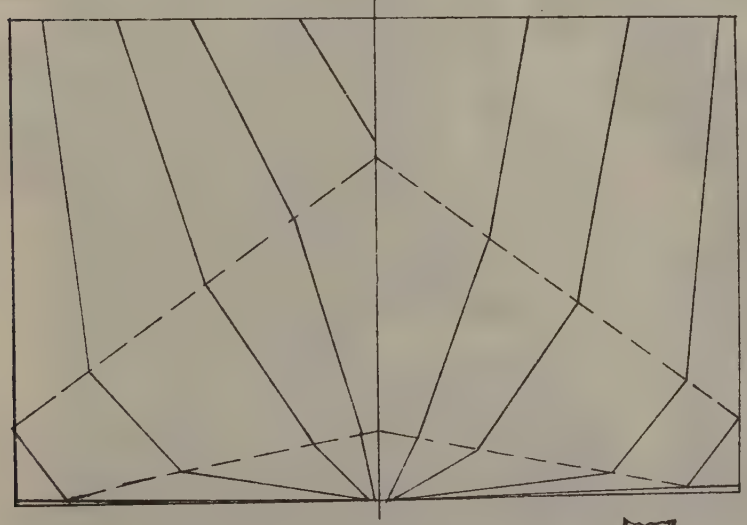
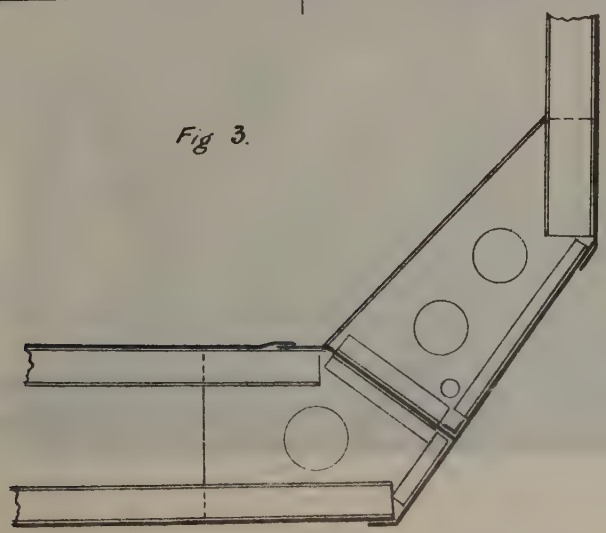
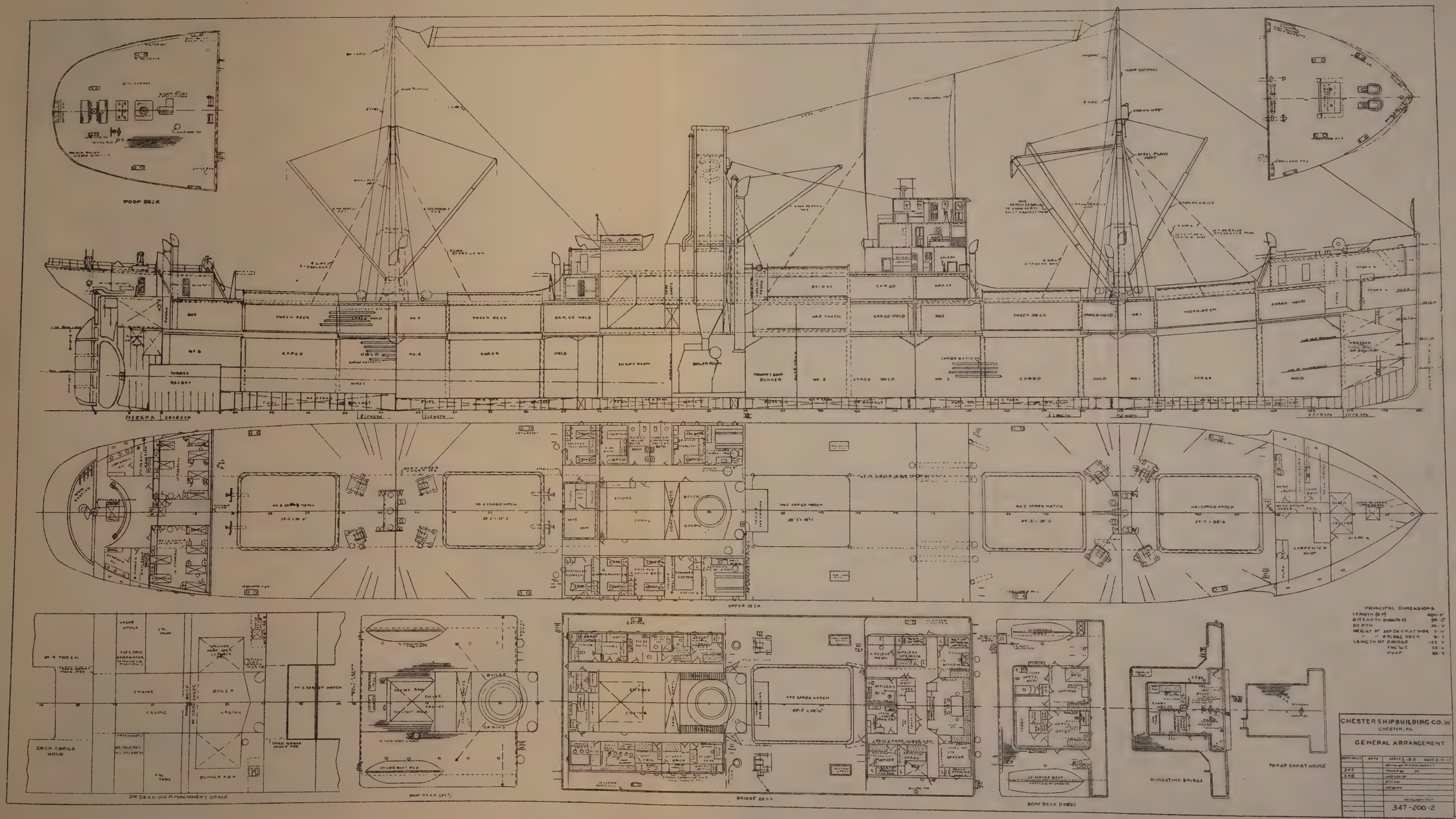


Fig 3.



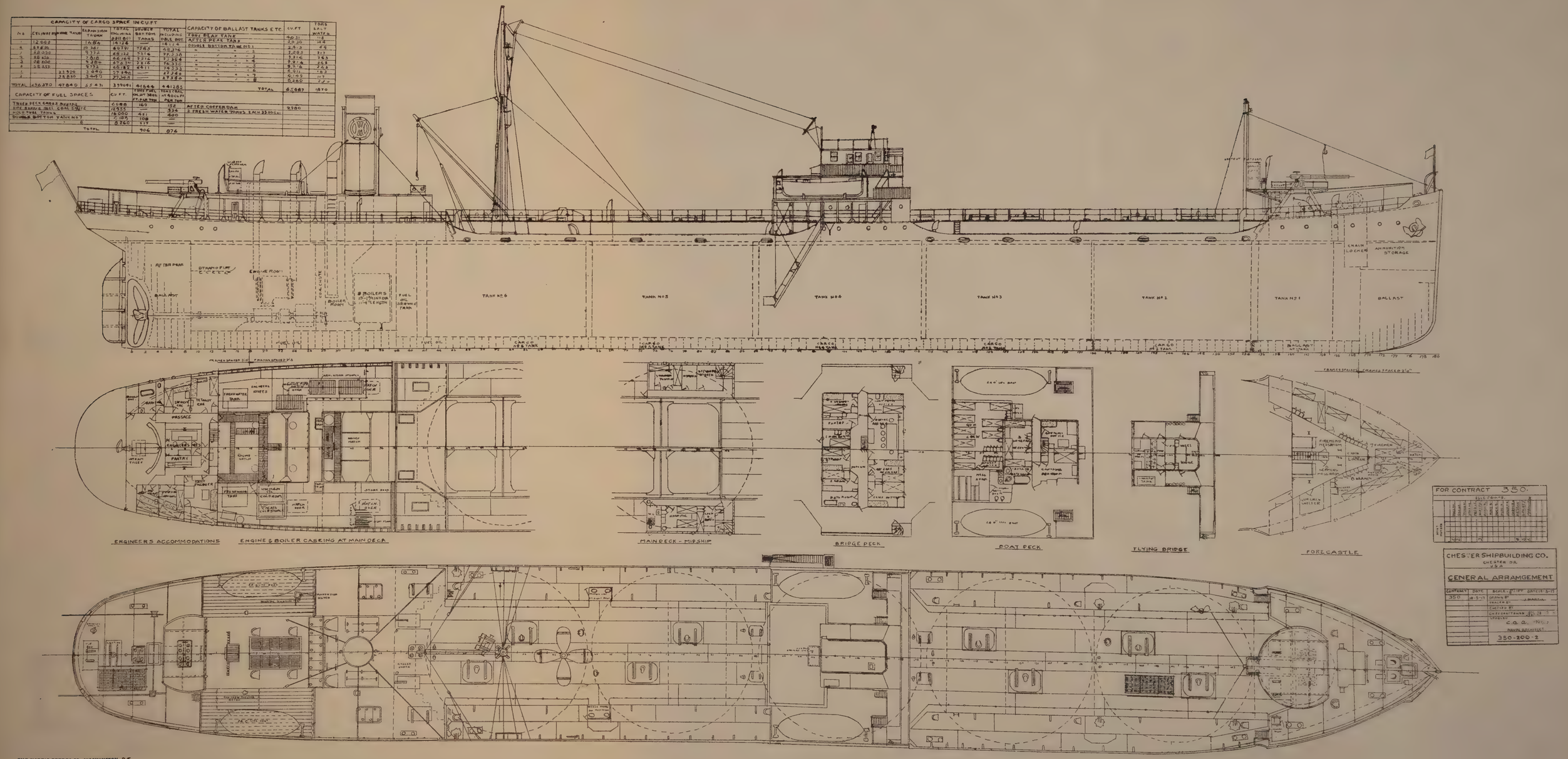
To illustrate paper on "Fabricated Ships," by R. H. M. Robinson, Member of Council.

To illustrate paper on "Fabricated Ships," by R. H. M. Robinson, Member of Council.



THE NORRIS PETERS CO., WASHINGTON, D. C.

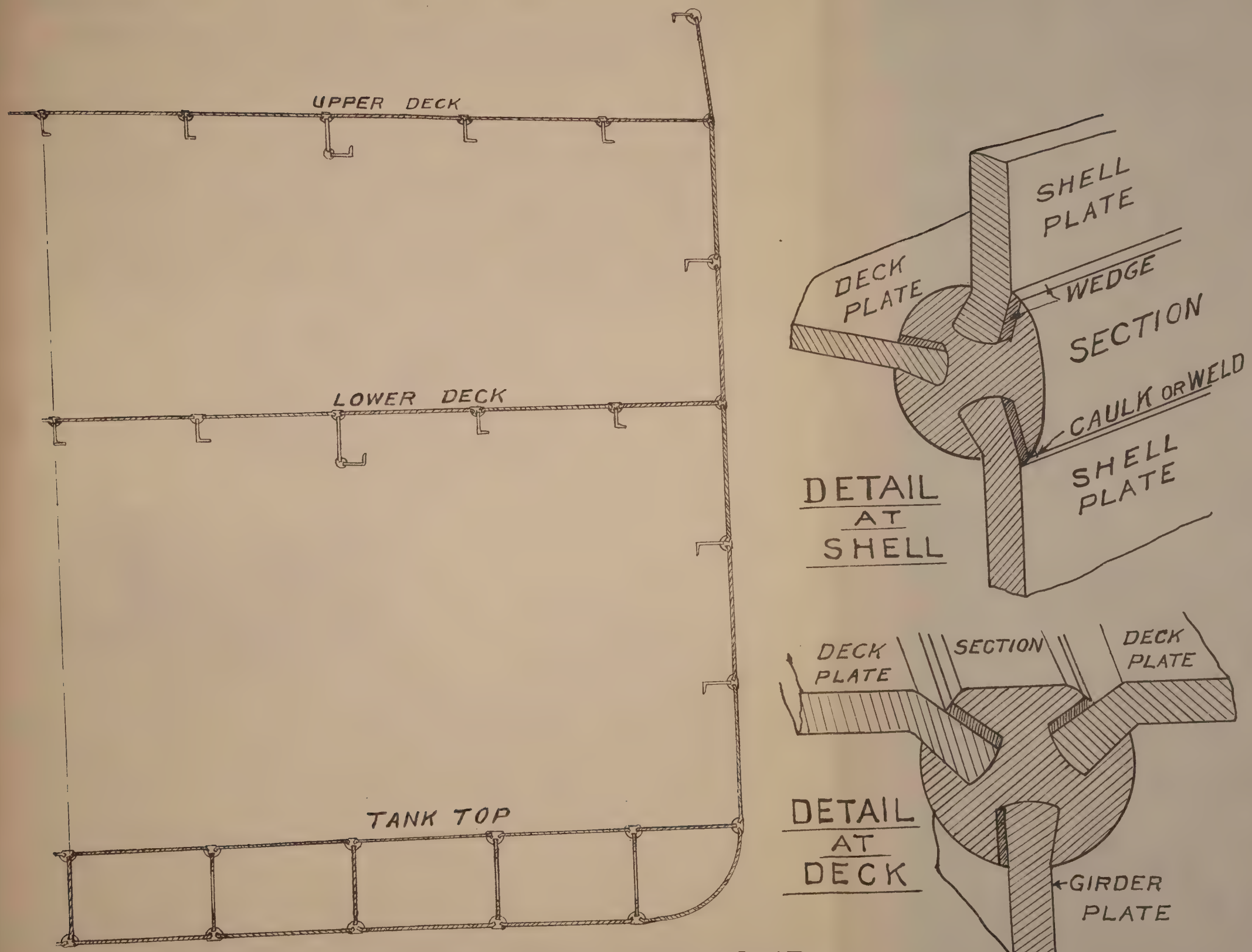
To illustrate paper on "Fabricated Ships," by R. H. M. Robinson, Member of Council.



THE NORRIS PETERS CO., WASHINGTON, D.C.

Transactions Society Naval Architects and Marine Engineers, Vol. 25, 1917.

To illustrate discussion by Clifton Yeomans, Esq., Member, on paper entitled "Fabricated Ships," by R. H. M. Robinson, Esq., Member of Council.



MIDSHIP SECTION CARGO STEAMSHIP
QUICK CONSTRUCTION SYSTEM

To illustrate paper on "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

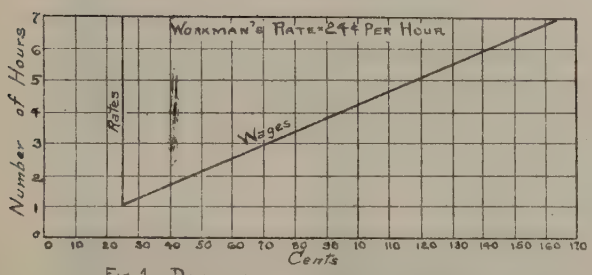
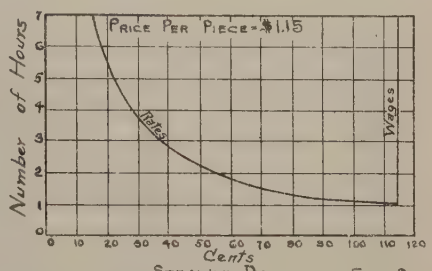
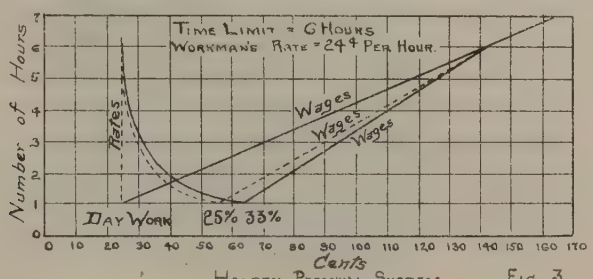


Fig. 1 Daywork



Straight Piecework Fig. 2



Halsey Premium System Fig. 3

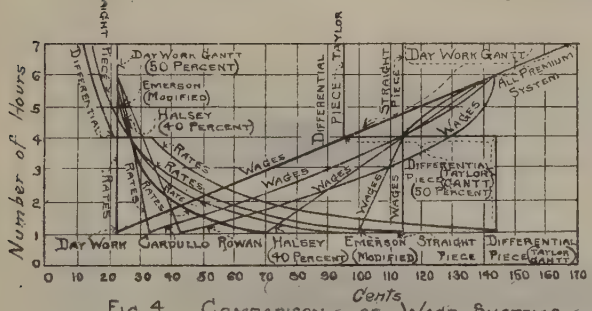
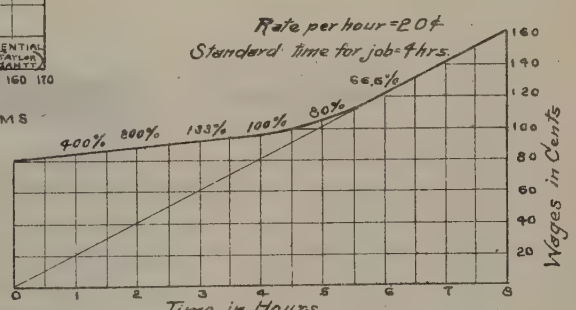


Fig. 4 Comparison of Wage Systems



Emerson System Fig. 5

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

OBSERVATION SHEET

ORDER NO 12z 5712 DATE SEPT 1910

PIECE HAND HOLE PLATES FOR B & W BOILERS

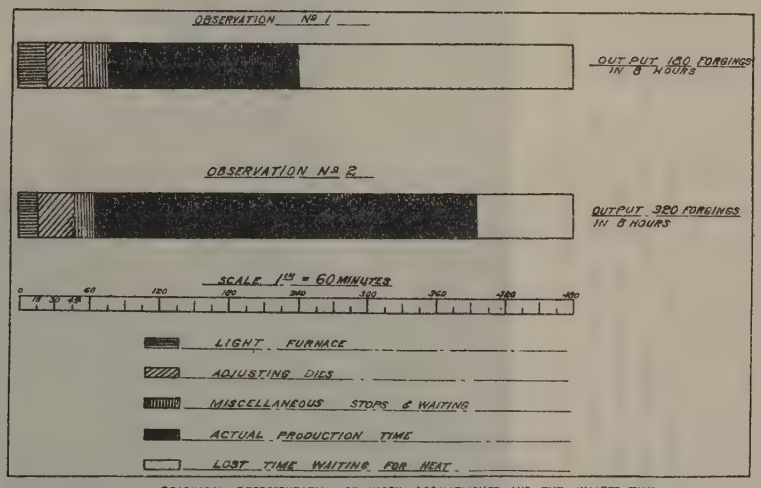
OPERATION ROUGH FORGING DIE = 5-36

MACHINE DROP HAMMER NO 2 WORKMAN WULSEY

SHEET NO 3 TIME 9:30 A M TO 10 A M

TIME	LIGHT FURNACE	WAITING FOR HEAT	FORGING PRODUCTION TIME	ADJUSTING DIES	MISC'S WAITING	NUMBER OF FORGINGS MADE	BARS OF STOCK PLACED IN FURNACE	REMARKS
9.30 To 31				10			X X	
32		30	20					
33						–		
34						–	X	
35						–		
36		35 10	25			–		
37			20 10					
38		15	35			–	X	
39						–		
40			15 30	15		–		
41						–		
42						–		
43		25 10	35			–		
44			50				X X	
45						–		
46						–		
47						–		
48		15	45			–		
49								
50		50	10					
51						–		
52						–		
53								
54						–		
55						–		
56								
57			25	35 5		–	X	
58					* 55 20			* DROW OF WATER
59			40					
10.00						–	X	
TOTAL	0-0	M. S. 4-10	M. S. 22-30	M. S. 2-05	M. S. 1-15	20	8	

FORM FOR OBSERVATION SHEET FOR TIME STUDIES TO DETERMINE DEFECTS IN METHODS OR EQUIPMENT.



GRAPHICAL REPRESENTATION OF WORK ACCOMPLISHED AND THE WASTED TIME

EXTRACTS FROM "COST KEEPING AND SCIENTIFIC MANAGEMENT" BY H. A. EVANS

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

Fig. 1.—A Full Wooden Shot, with the Driver, Posed by Gil Nicholls. In This Negative No Lights Were Used Except One—and That Was Attached a Trifle Above the Head of the Club. This is a Singularly Interesting Negative, in That the Entire Course Pursued by the Club-head is Accurately Reproduced in It. It will be Seen from a Study of This Picture That the Arc Described by the Club-head on the Up Swing is Not Exactly Like That Followed by It on the Down Swing. For Generations Professionals Have Taught Us That the Swing of the Club in Coming Down Should Be Exactly the Same as the Swing of It in Going Up, but We See Here, in Gil Nicholls—as Good a Model of Golfing Form as One Could Find Anywhere—That the Two Arcs Are Dissimilar and That the Down Swing is Considerably Closer to the Body Than the Up Swing.

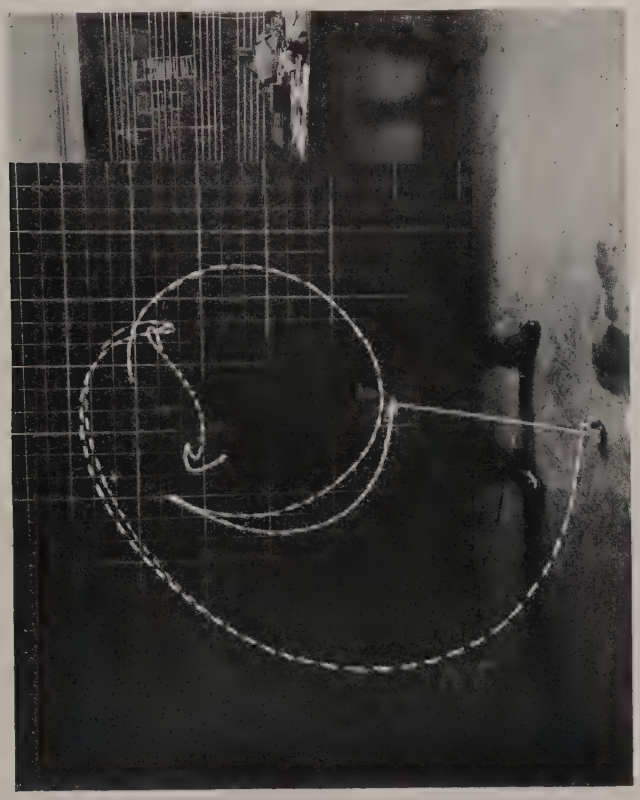


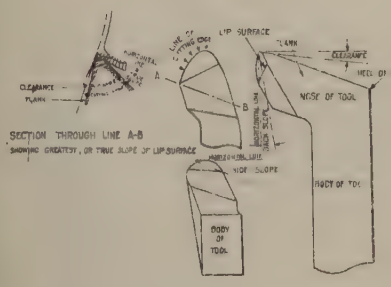
Fig. 2.—A Full Midiron Shot, by Gil Nicholls. In This Negative a Light was Used on the Club, a Light on the Right Hand, and a Light on the Player's Forehead. The Swing Up and the Swing Down are Fairly Well Shown, but the Light was Turned Off on the Head of the Club after the Contact of the Club with the Ball. It Will be Noted in This Picture, Just as it is in No. 1, That the Arc Described by the Descent of the Club is Not Exactly the Same as That Described by the Ascent of It.

The Trace of the Light on the Head is to be Noted, the Final Position at the End of the Stroke Being That on the Extreme Right with the Head Facing the Line of Flight of the Ball, and is to be Borne in Mind Particularly with Respect to the Standard Instructions of Keeping the Eye on the Ball.

To illustrate paper on "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

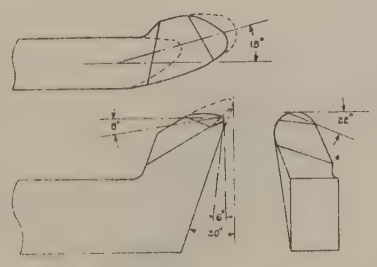
FINISH OF SWING. HARRY VARDON.

To illustrate paper on "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.



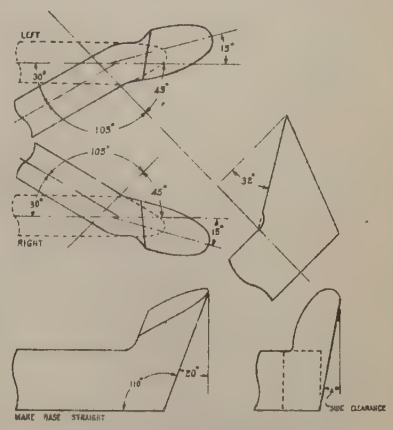
DRAWING SHOWING THE MEANING OF THE TERMS, BODY OF TOOL (SHANK), NOSE OF TOOL, FLANK OF TOOL, HEEL OF TOOL, LIP SURFACE OF TOOL, CLEARANCE ANGLE, BACK SLOPE, TRUE SLOPE, LIP ANGLE, CUTTING ANGLE AND LINE OF CUTTING EDGE

FIG. 1



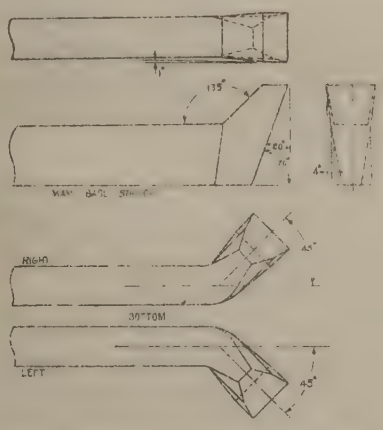
ROUND-NOSE ROUGHING TOOLS

FIG. 2



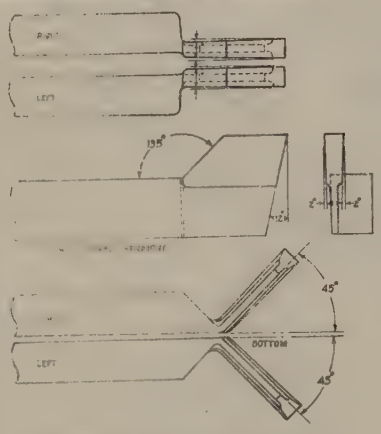
BENT ROUND-NOSE ROUGHING TOOLS

FIG. 3



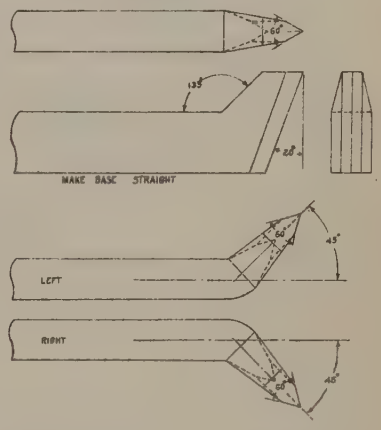
STRAIGHT AND BENT SQUARE-NOSE FINISHING TOOLS

FIG. 4



STRAIGHT AND BENT PARTING TOOLS

FIG. 5



STRAIGHT AND BENT 60° "V" THREAD TOOLS

FIG 6

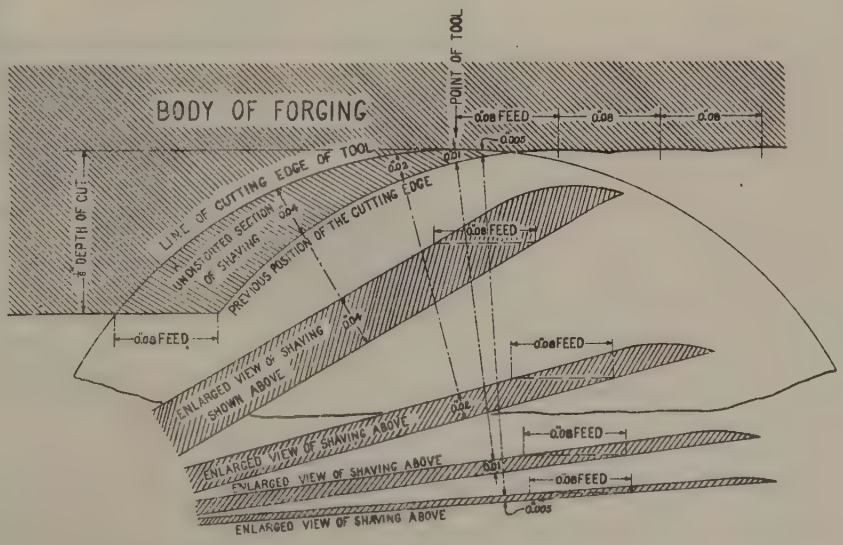


FIG. 7

THE NORRIS PETERS CO., WASHINGTON, D. C

To illustrate paper on "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

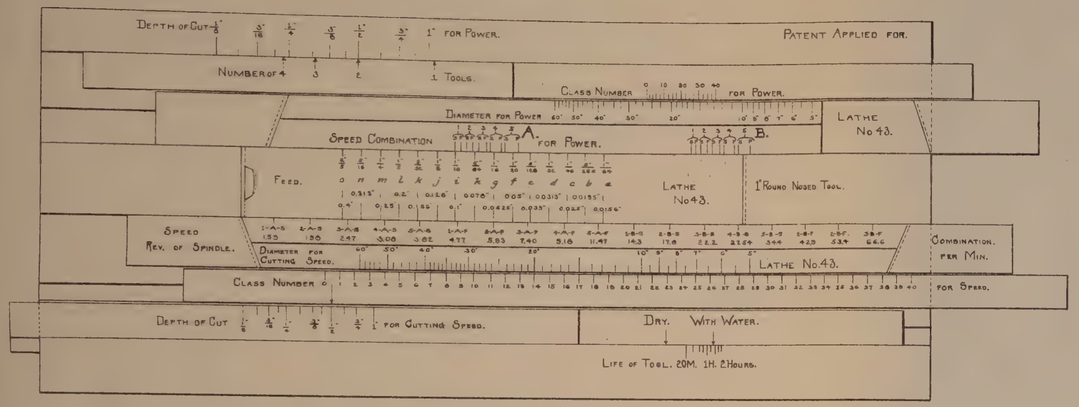


FIG. 1

FOR SPEED, FEED AND DEPTH OF CUT

FIG. 2

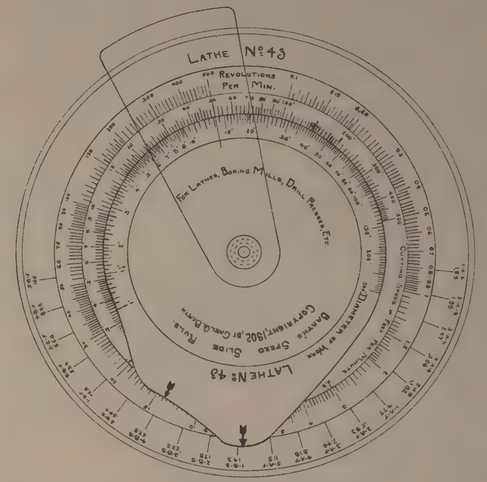


FIG. 3

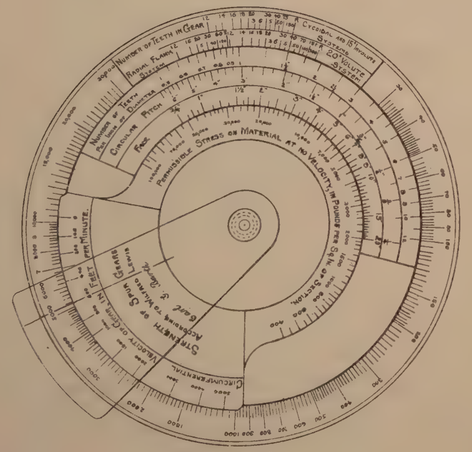


FIG. 4

THE BARTH SLIDE RULES

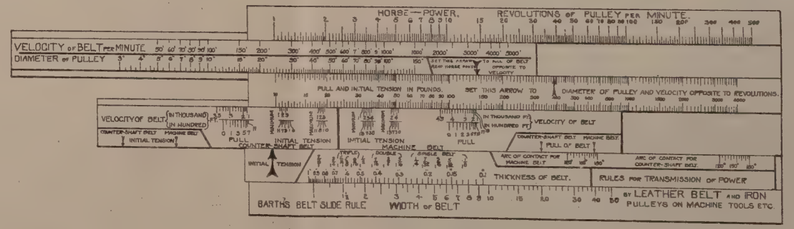


FIG. 5

BELT SLIDE RULE

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

As Used at Watertown Arsenal

53 PAGES. PAGE 1A.
Assembling charts for Mount for 14" Turret, Model 1909. RK14T containing
Index.
Ex-Order [redacted]
Watertown Arsenal, Mass.
May 17th, 1911.

INDEX
RK14T MOUNT FOR 14" TURRET MOD. 1909

SYMBOL	GROUPS	PAGE	DVN
RK14TA	Shipper Group,	20	0
RK14TB			
RK14TC	Cradle Group,	3	3
RK14TD	Range Dial Group,	16	5
RK14TE			
RK14TF	Friction Coupling Shaft,	13	0
RK14TG	Motor Gear Bracket,	13	0
RK14TH	Motor Shaft Bearing,	22	0
RK14TJ	Hand Elevating Gear Bracket Group,	11	0
RK14TK	Switch Shaft Group,	22	0
RK14TL	Elevating Group,	8	7
RK14TM	Miscellaneous Group,	28	0
RK14TN	Breach Opening Devise Group,	29	9
RK14TP	Pedestal Group,	10	3
RK14TR	Shaft Extension Group,	11	0
RK14TS	Gas Ejector Group,	27	2
RK14TT	Tension Carriage Group,	14	0
RK14TU			
RK14TV	Vertical Shaft Group,	14	0
RK14TW	Slanting Sheave Bracket,	15	0
RK14TX	Bent Sheave Bracket,	15	0
RK14TY	Yoke Group,	2	1
RK14TZ	Straight Sheave Bracket,	15	0

	SYMBOL	DIVISIONS	PAGE	SCS
RK14TC	RK14TCC	Recoil Cylinder Div.	4	3
	RK14TCK	Cradle Division,	6	0
	RK14TCM	Miscellaneous,	3	0
RK14TD	RK14TDD	Dial Wheel Division,	16	0
	RK14TDF	Frame Division,	18	0
	RK14TDM	Miscellaneous,	18	0
	RK14TDR	Guide Rail Division,	17	0
	RK14TDW	Weight Division,	17	0
RK14TL	RK14TLB	Buffer Division,	9	0
	RK14TLL	Lower Ball Bearing,	7	0
	RK14TLM	Miscellaneous,	8	0
	RK14TLN	Elevating Nut Div.	12	0
	RK14TLS	Elevating Screw,	7	0
	RK14TLT	Elevating Transom,	8	0
	RK14TLU	Upper Ball Bearing,	7	0
RK14TN	RK14TNB	Buffer Division,	25	0
	RK14TNF	Friction Coupling,	23	0
	RK14TNH	Hollow Shaft,	23	0
	RK14TNL	Lever Division,	24	0
	RK14TNM	Miscellaneous,	26	
	RK14TNR	Reversing Mechanism	21	2
	RK14TNS	Steady Bearing,	20	0
	RK14TNV	Vertical Shaft,	24	0
	RK14TNX	Cushion Division,	25	0

SYMBOL	DIVISIONS	PAGE	SCS
RK14TPD	Door Division,	9	0
RK14TPM	Miscellaneous,	10	0
RK14TPP	Pedestal Division,	9	0
RK14TSM	Miscellaneous,	27	0
RK14TSV	Valve Division,	26	0
RK14TYY	Yoke Division,	5	0

SYMBOL	SECTIONS	PAGE
RK14TCCF	Front Piston Rod Nut,	4
RK14TCCN	Rear Piston Rod Nut,	3
RK14TCCV	Filling Valve,	3
RK14TNRD	Gear Case Door,	20
RK14TNRG	Gear Case Section,	19

PAGE	BY PAGES
1	Index
2	RK14TY.
3	RK14TC, RK14TCCV, RK14TCCN
4	RK14TCCF, RK14TCC.
5	RK14TYY.
6	RK14TCK.
7	RK14TLS, SRK14TLU, SRK14TLL
8	RK14TLT, RK14TL.
9	RK14TPD, LK14TPD, RK14TPP.
10	RK14TP
11	RK14TR, RK14TJ.
12	RK14TLN.
13	RK14TF, RK14TG.
14	RK14TV, RK14TT.
15	RK14TW, RK14TX, RK14TZ.
16	RK14TBD.
17	RK14TDW, RK14TDR.
18	RK14TDF, RK14TD.
19	RK14TLB, RK14TNRG.
20	RK14TNRD, RK14TNS, RK14TNA
21	RK14TNR.
22	RK14TH, RK14TK.
23	RK14TNF, RK14TNH.
24	RK14TNL, RK14TNV.
25	RK14TNB, RK14TNX.
26	RK14TN, RK14TSV.
27	RK14TS.
28	1RK14T – 2RK14T.
29	3RK14T – 4RK14T.
30	5RK14T – 6RK14T.
31	7RK14T – 8RK14T.
32	RK14T Comp.

53 Pages — Page 3
Assembling charts for Mount for 14" Turret, Mod. 1909. RK14T containing
Cradle Group, RK14TC
Filling Valve Section, RK14TCCV
Rear Piston Rod Nut Sec, RK14TCCN
Ex-Order [redacted]
Watertown Arsenal, Mass.
June 8th, 1911.

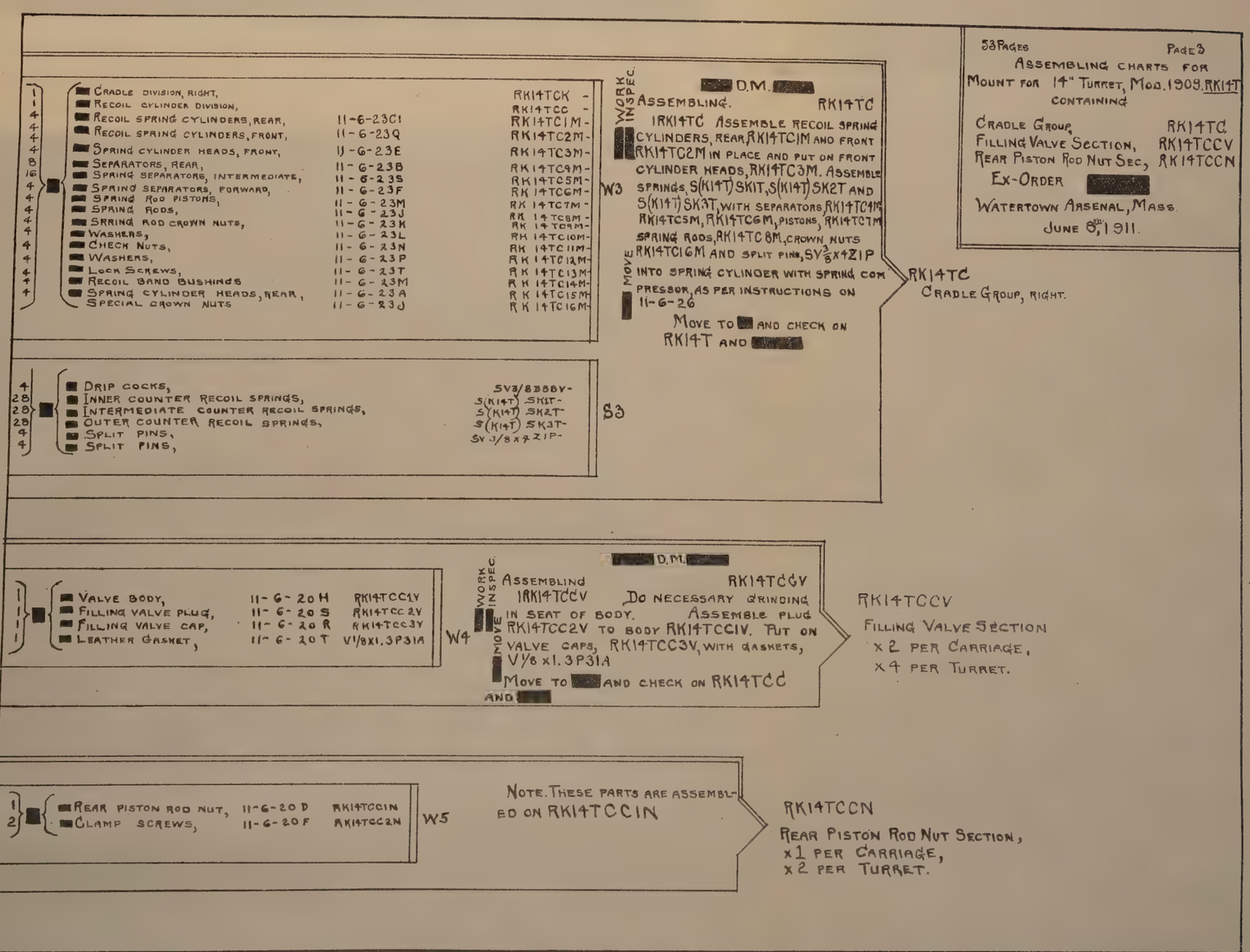
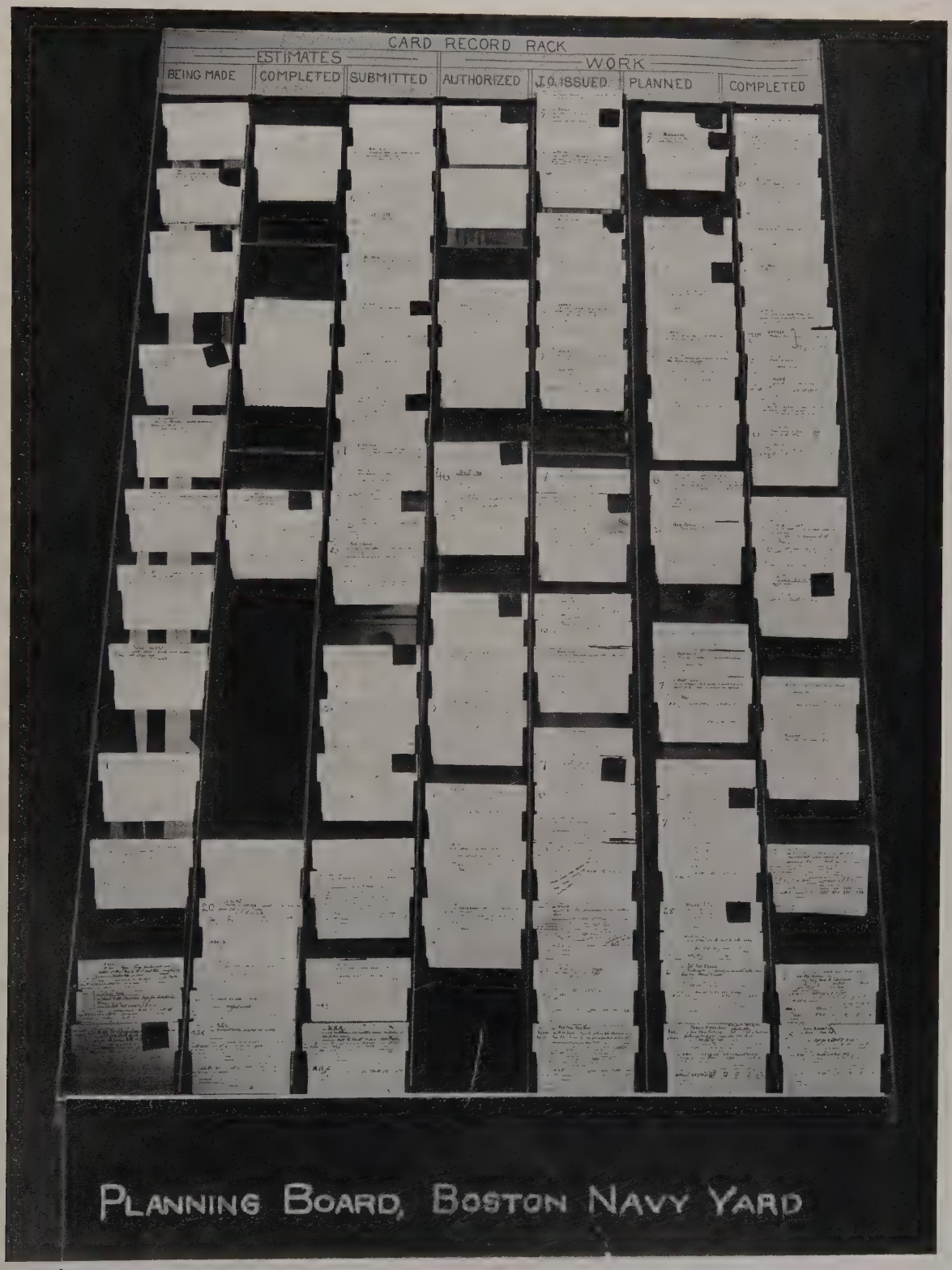


Fig 1 Assembling Chart for Groups of Turret Gun Parts, 14 x 19 in.

THE NORMAN PETERS CO., WASHINGTON, D. C.

To illustrate paper on "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.



PLANNING BOARD, BOSTON NAVY YARD

To illustrate paper on "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

As Used at Watertown Arsenal

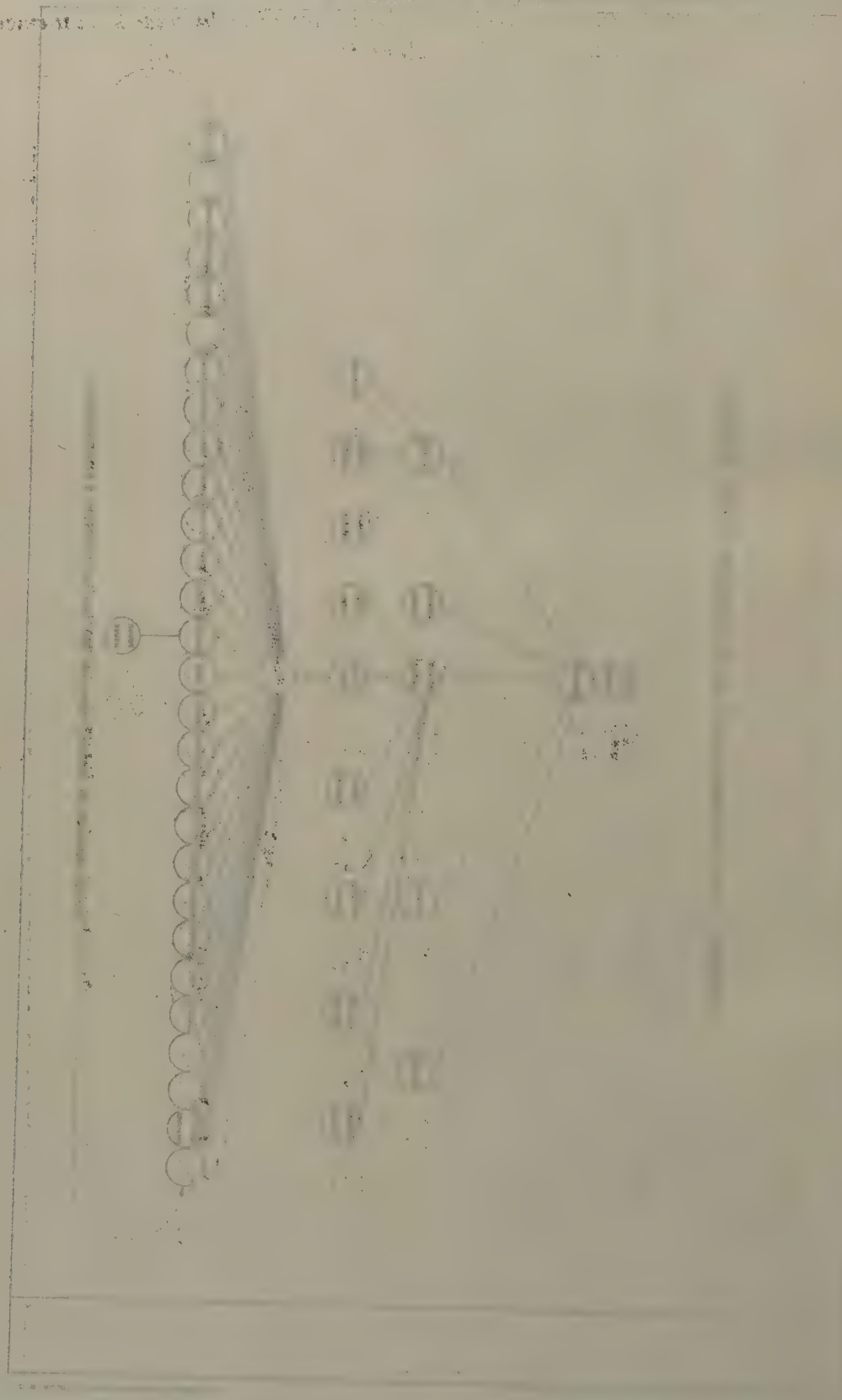
KIND OF UNIT _____ QUANTITY TO BE KEPT ON HAND MAX. _____ SYMBOL

BALANCE OF STORES. DESCRIPTION _____ MIN. _____

NOTE—WHEN STORES ARE ORDERED, ADD THE QUANTITY TO COLUMNS 1 AND 4. WHEN STORES ARE RECEIVED SUBTRACT THE QUANTITY FROM COL. 1 AND ADD THE QUANTITY TO COLUMN 2. WHEN STORES ARE APPORTIONED, SUBTRACT QUANTITY FROM COL. 4 AND ADD QUANTITY APPORTIONED TO COL. 3. WHEN STORES ARE ISSUED SUBTRACT QUANTITY FROM COLUMNS 2 AND 3. IN ALL CASES BRING DOWN AT ONCE BALANCE ON HAND IN EACH COLUMN AFFECTED.

1—STORES ORDERED BUT NOT YET DELIVERED					2—STORES ON HAND IN THE STOREROOM					3—STORES APPORTIONED TO AN ORDER BUT NOT YET ISSUED FROM STORE RM					4—STORES AVAILABLE THAT IS: ON ORDERS AND ON HAND		
DATE ORDERED	PURCHASE ORDER NUMBER	QUANTITY	TOTAL COST	DATE REC'D	QUANTITY	DATE ISSUED	ISSUED TO ORDER NO.	TOTAL COST	COST PER UNIT	DATE APPORTIONED	QUANTITY	APPORTIONED EX ORD OR REQ.	APPROP	TOTAL COST	DATE ISSUED	DATE	QUANTITY	REMARKS

THE NORRIS PETERS CO., WASHINGTON, D. C.



To illustrate discussion by Major Frank B. Gilbreth, U. S. A., on paper entitled "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

Fig. 1.—Paths of Lights (Chromocyclegraphs) of Head, Right Hand and Left Hand of Bricklayer Handling Brick (with Left Hand) and Mortar (with Right Hand), While Laying Four Brick in the Usual Old Method. Note the Small Kinks in the Paths Which Show Where the Brick Was "Positioned" (Flopped) During "Transport Loaded," Which Affects the Head Line Also as Seen in the Line at the Extreme Left.

Fig. 2.—Side View of Bricklayer Laying Four Brick in Old Way. Note the Effect in the Line Showing Path of the Head by Reason of the Brick Being "Positioned" (Flopped) During "Transport Loaded."

To illustrate discussion by Major Frank B. Gilbreth, U. S. A., on paper entitled "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

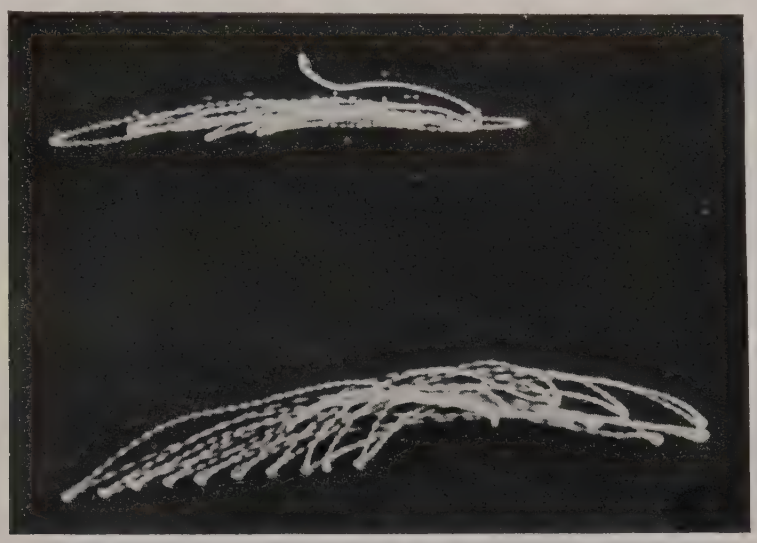


Fig. 1.—Paths of Lights (Chromocyclegraphs) of Head and Left Hand While Laying Ten Brick With New Method. Arranging the Brick in a Systematic Pile of Packs or on the Anti-fatigue Scaffold Enables the Bricklayer to Make His Motions in a More Nearly Horizontal Path. This Eliminates Bending and is a Good Illustration of an Instance Where "Direction" of Motions is an Important Variable. The Motion Was Made in the Direction of the End of the Spot Which is Most Pointed.

Fig. 2.—Cyclegraphs of Paths of Surgeon Sewing up Abdomen.

To illustrate discussion by Major Frank B. Gilbreth, U. S. A., on paper entitled "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

Fig. 1.—Movements Entailed in Loading Sixteen Boxes on to a "Move-Truck." Old Method.

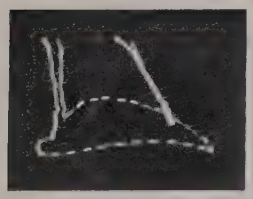
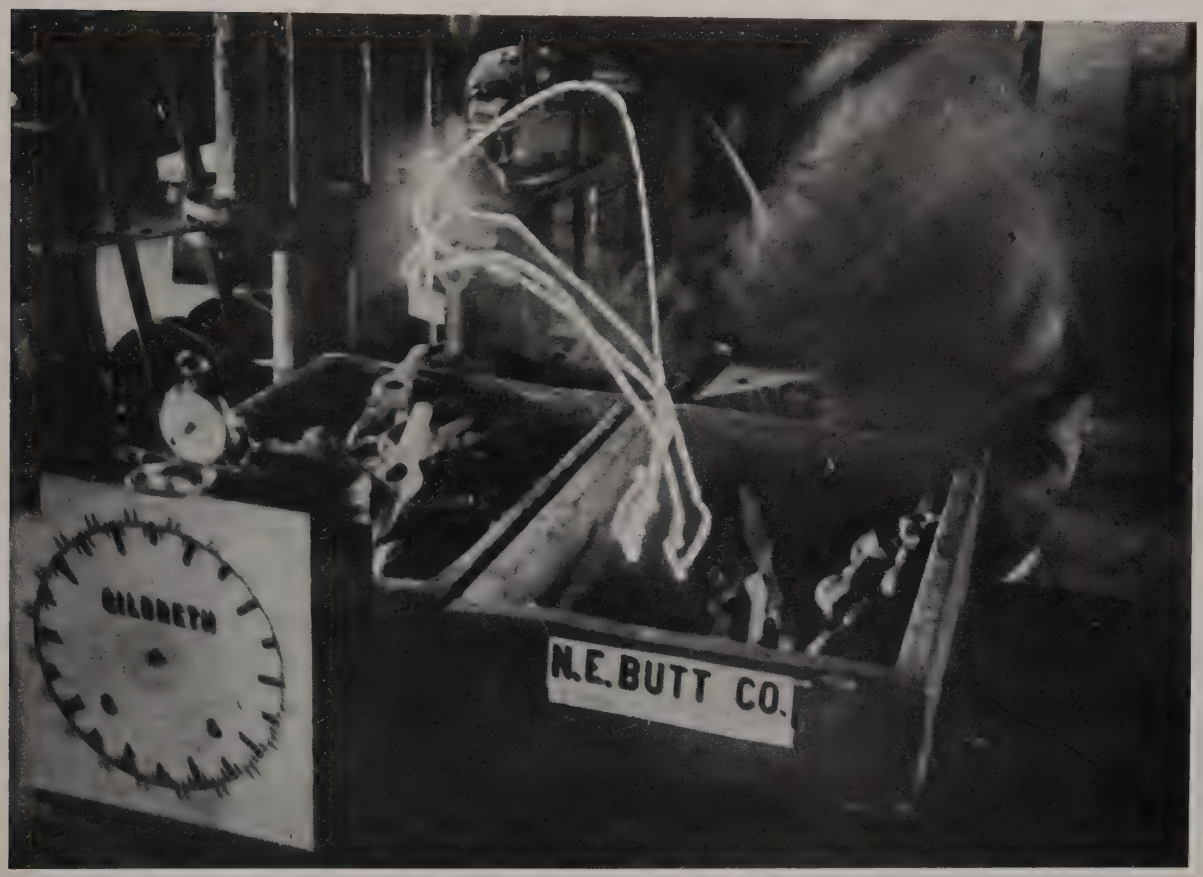


Fig. 2.—Movements Entailed in Loading Sixteen Boxes on to a "Move-Truck." New Method.

To illustrate discussion by Major Frank B. Gilbreth, U. S. A., on paper entitled "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

Cyclegraph on Drill Press. Notice "Hesitation" Before Grasp.

To illustrate discussion by Major Frank B. Gilbreth, U. S. A., on paper entitled "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.



Cyclegraph of Foreman's Left Hand on a Drill Press Repeating Operation Twice. Note "Hesitation" Just Before "Grasp." See *610-G 225* for Double Cyclegraph after a Little More Practice.

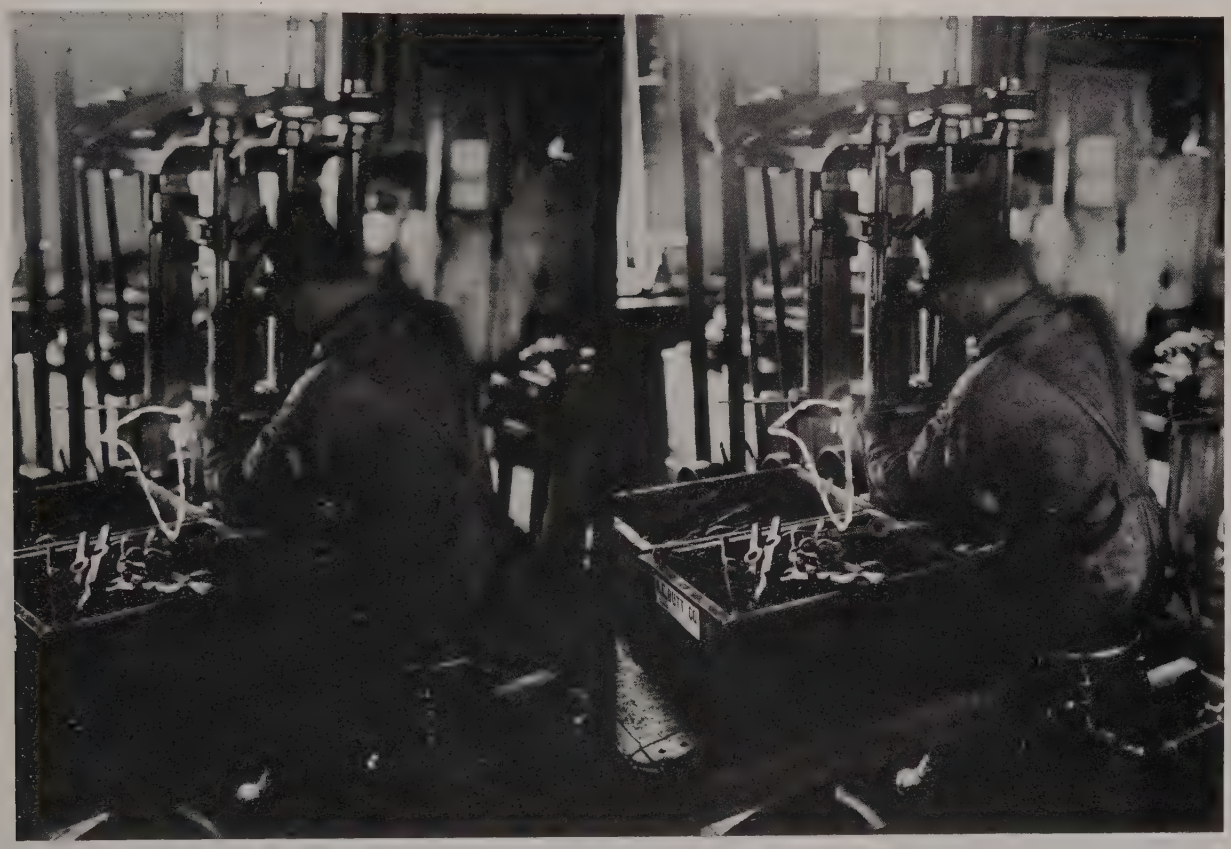
To illustrate discussion by Major Frank B. Gilbreth, U. S. A., on paper entitled "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

One of the First Photographs of "Habit." The Twist in the Line of "Transport Loaded" is the "Positioning Motions."

To illustrate discussion by Major Frank B. Gilbreth, U. S. A., on paper entitled "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

Cyclegraph of Left Hand on Drill Press Showing "Positioning" of Piece All the Time During "Transport Loaded." Note no "Hesitation" before "Grasp."

To illustrate discussion by Major Frank B. Gilbreth, U. S. A., on paper entitled "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.



Ideal Cycle for This Particular Set Up. No "Hesitation," no "Positioning."

To illustrate discussion by Major Frank B. Gilbreth, U. S. A., on paper entitled "An Analysis of the Principles of Industrial Management," by Naval Constructor T. G. Roberts, U. S. N., Member.

Fig. 1.—First Picture Showing Wire Models of Progress of Learning Best Paths of Motions.

Fig. 2.—Assembly Pockets for Assembling Braiding Machines. This Resulted in the Men Doing Over Three Times as Much Work with Less Fatigue.

Fig. 3.—Assembly Wall Pockets for Holding Materials in an Obvious Sequence for an Assembler. This and Other Improvements Due to Motion Study Resulted in Those Assemblers Doing over Three Times as Much Work with Less Fatigue. For Details See Fig. 14.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

Fig. 1.—A Number of Stabilizers for Various Size Vessels.

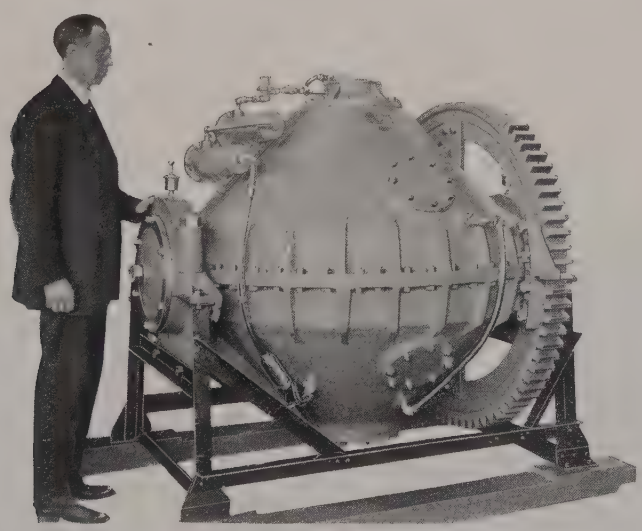


Fig. 2.—Gyro Unit for 460-Ton Yacht.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

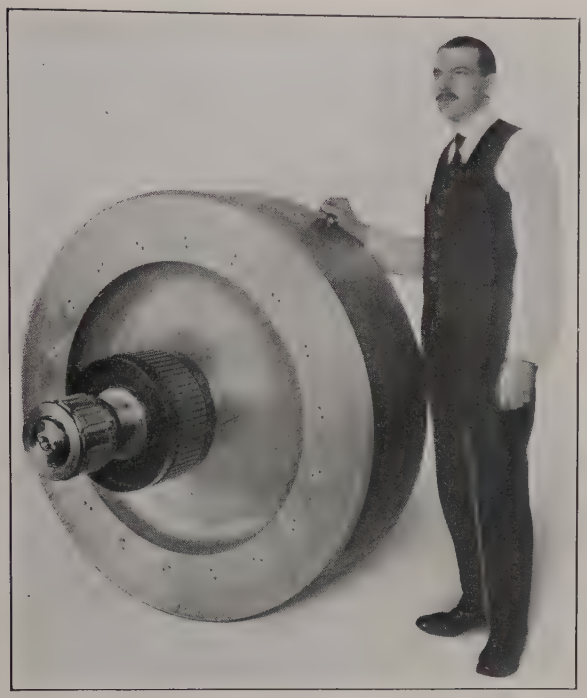


Fig. 3.—Gyro Wheel for Vessel of 550 Tons Displacement.

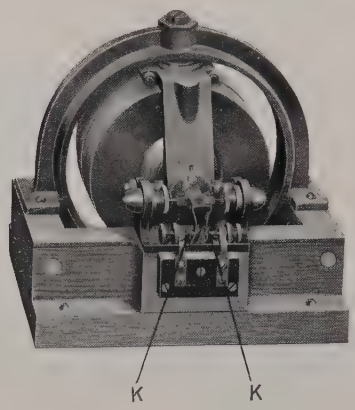


Fig. 4.—Control Gyro.

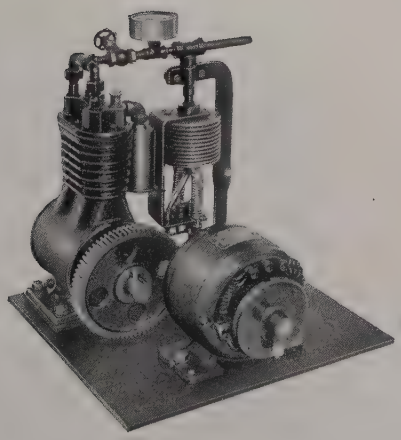


Fig. 5.—Vacuum Control Unit.

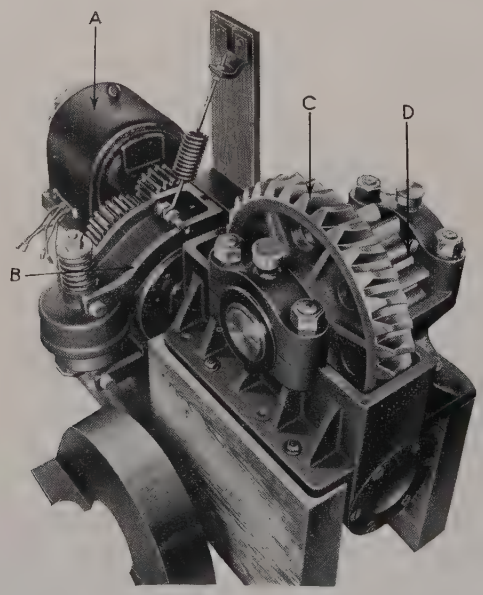


Fig. 6.—Precession Unit.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

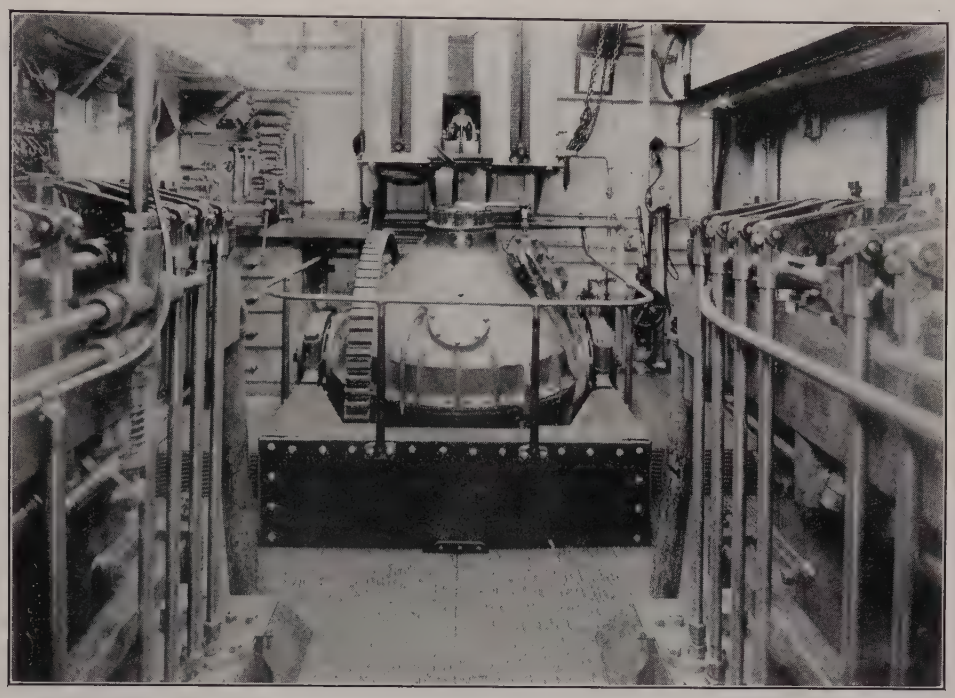


Fig. 7.—Stabilizer Installed in Engine Room U. S. S. Aramis.

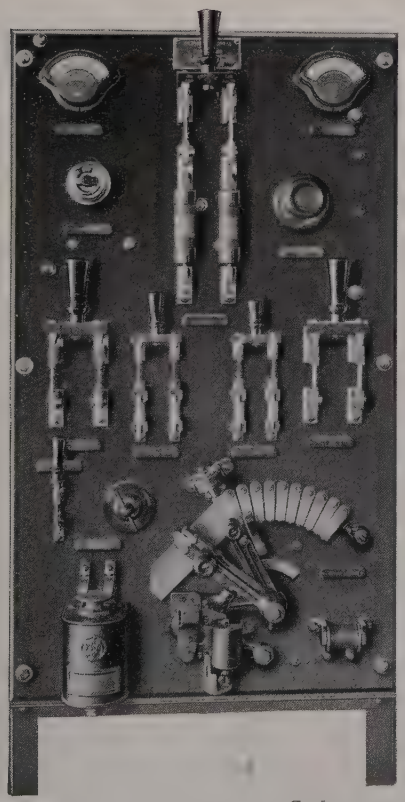


Fig. 8.—Standard Stabilizer Switchboard.

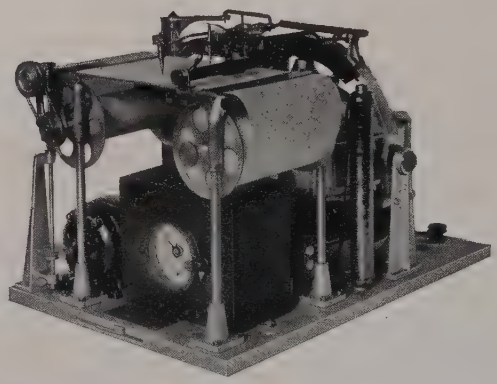


Fig. 9.—Gyroscopic Roll and Pitch Recorder.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

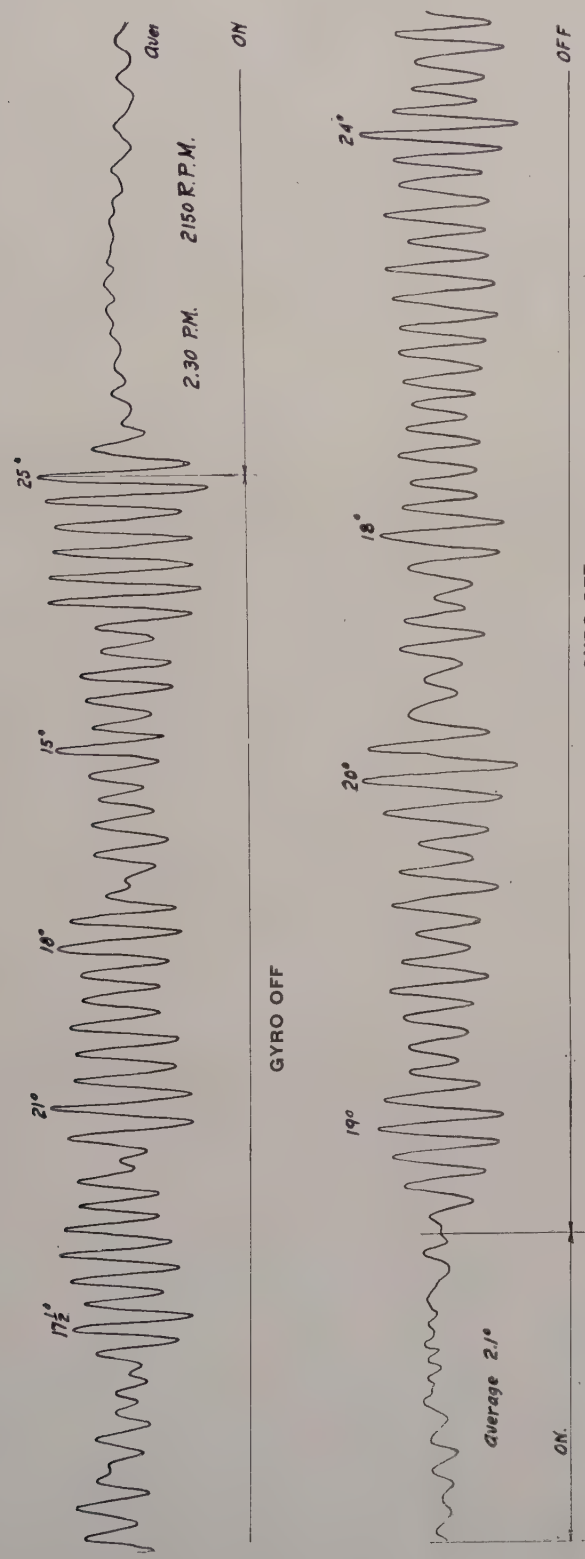


Fig. 10 and Fig. 11.—Free Rolling Curves Without Stabilizing, U. S. S. Aramis.

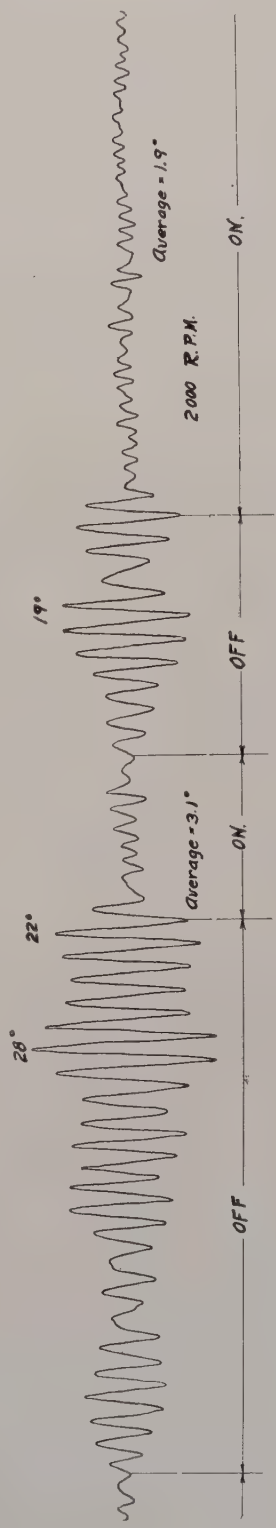
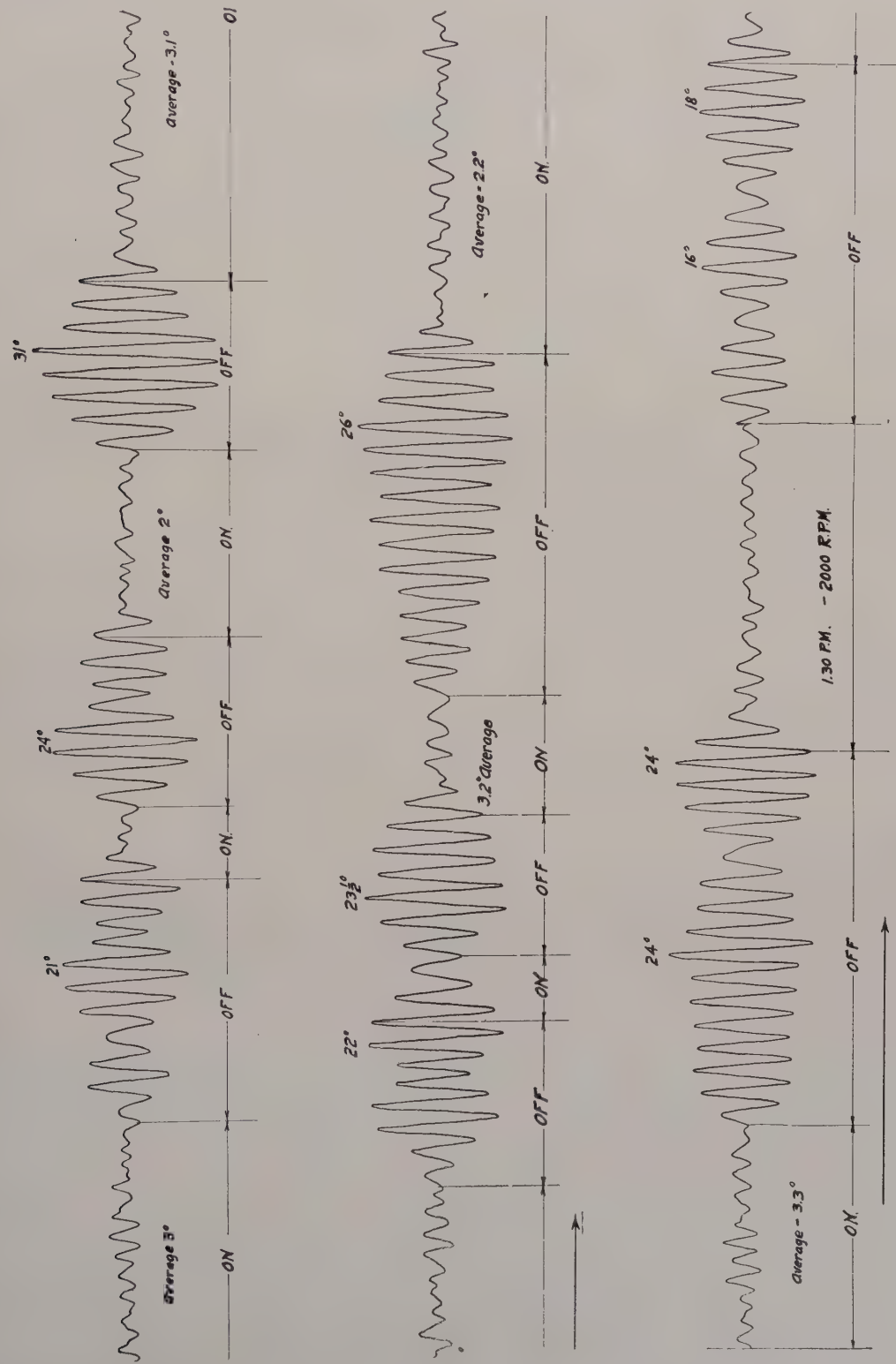


Fig. 12.—Sections from Stabilizing Curves, U. S. S. Aramis.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.



FIGS. 13, 14, 15.—SECTIONS FROM STABILIZING CURVES, U. S. S. ARAMIS.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

Fig. 16.—Small Stabilizer for Submarine Patrol Boat.

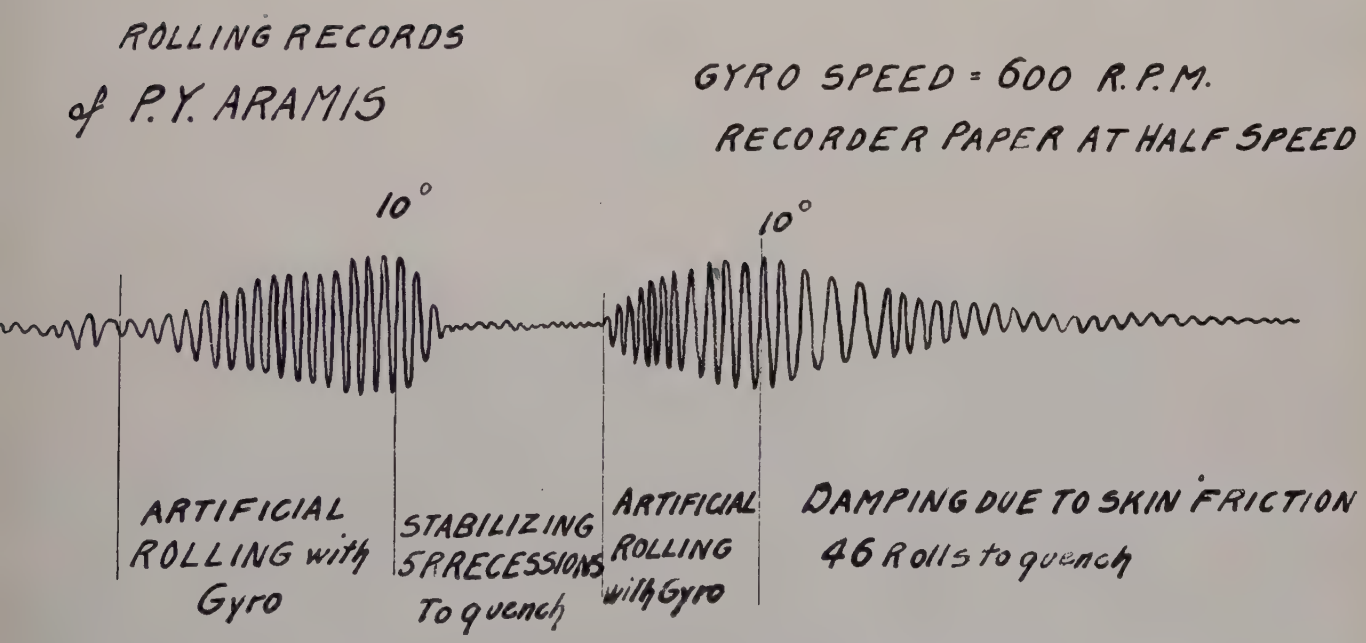


Fig. 17.—Gyro Rolling and Stabilizing Curves, U. S. S. Aramis.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

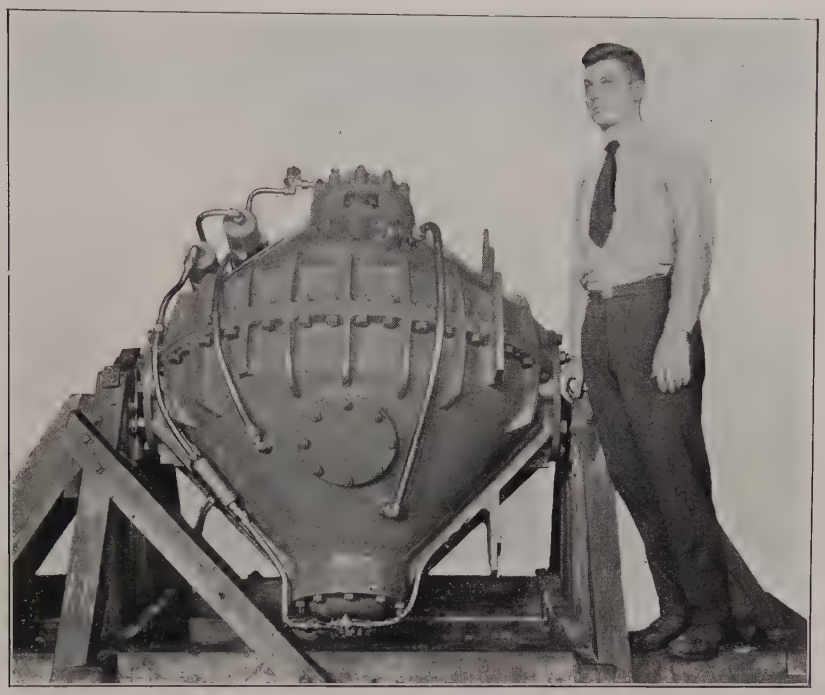


Fig. 18.—Gyro Unit for 300-Ton Boat.

Fig. 19.—Gyro Unit, U. S. S. Isabel.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

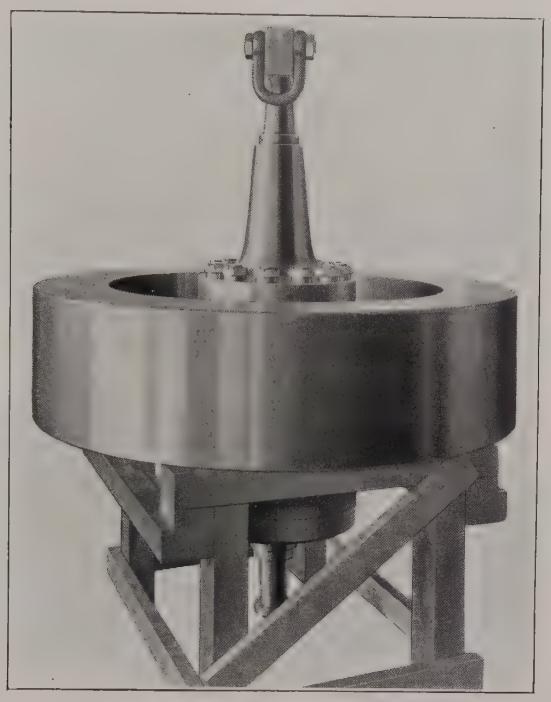


Fig. 20.—Wheel for U. S. S. Isabel Stabilizer.

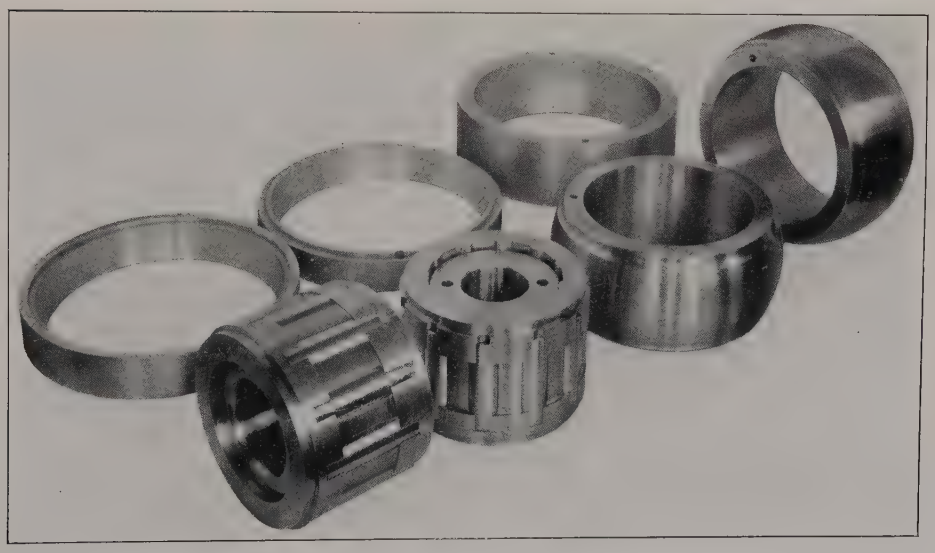


Fig. 21.—Special Roller Bearings for U. S. S. Isabel Stabilizer.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

Fig. 22.—Passive Stabilizer for Special Type of Vessel.

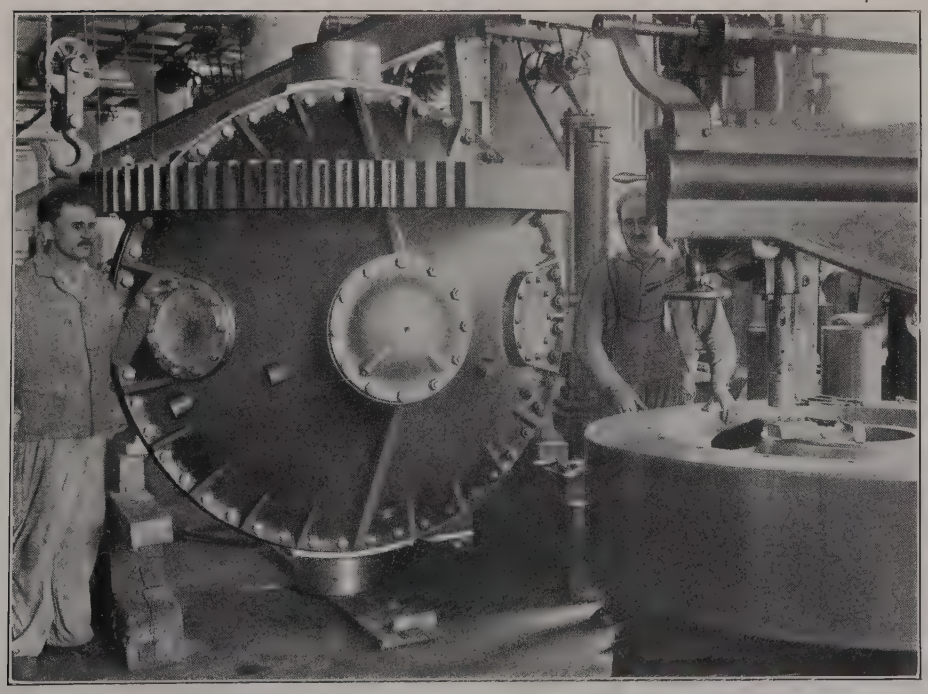


Fig. 23.—14-Ton Stabilizer for 1,500-Ton Ship.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

Fig. 24.—56,000-Pound Casting for Large Stabilizer Rotor.

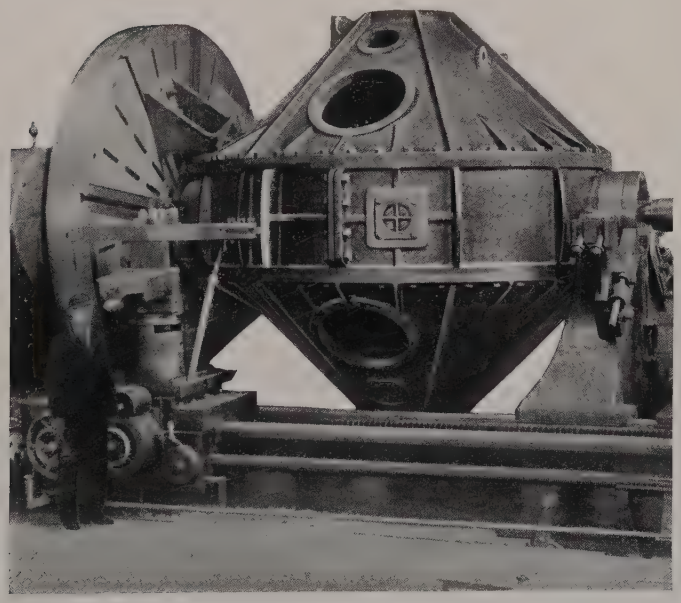


Fig. 25.—Casing for Large Stabilizer Equipment.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

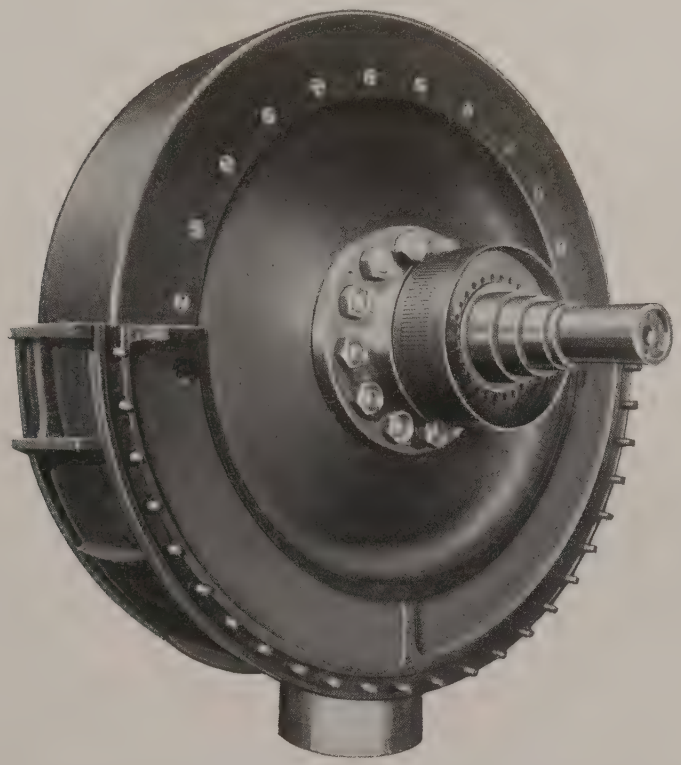


Fig. 26.—25-Ton Gyro Assembling in Casing.

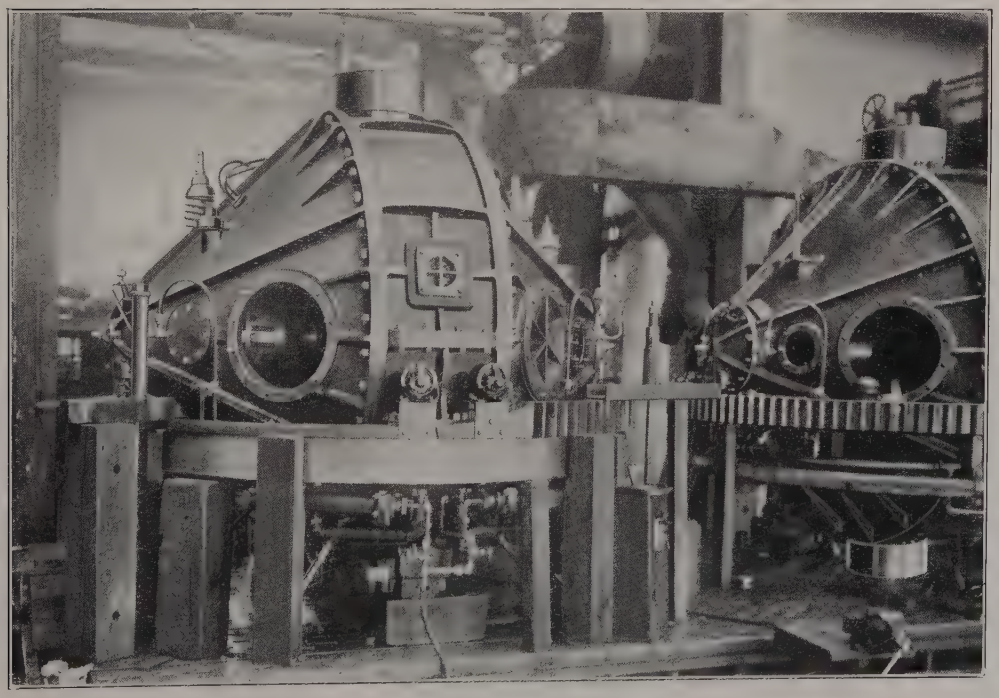


Fig. 27.—Gyro Wheels During Balancing.

To illustrate paper on "Gyro Ship Stabilizers in Service," by Elmer A. Sperry, Esq., Member.

FIG. 28.—COMPARATIVE SIZE OF STABILIZER FOR 10,000-TON VESSEL.

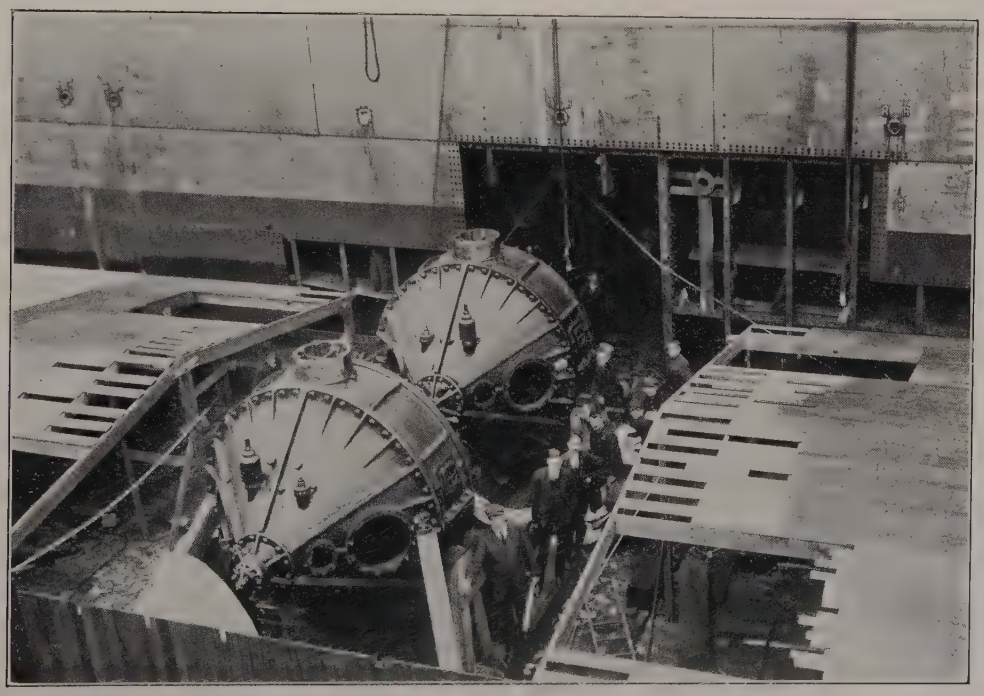


FIG. 29.—CLOSE VIEW OF LARGE STABILIZER UNITS.

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